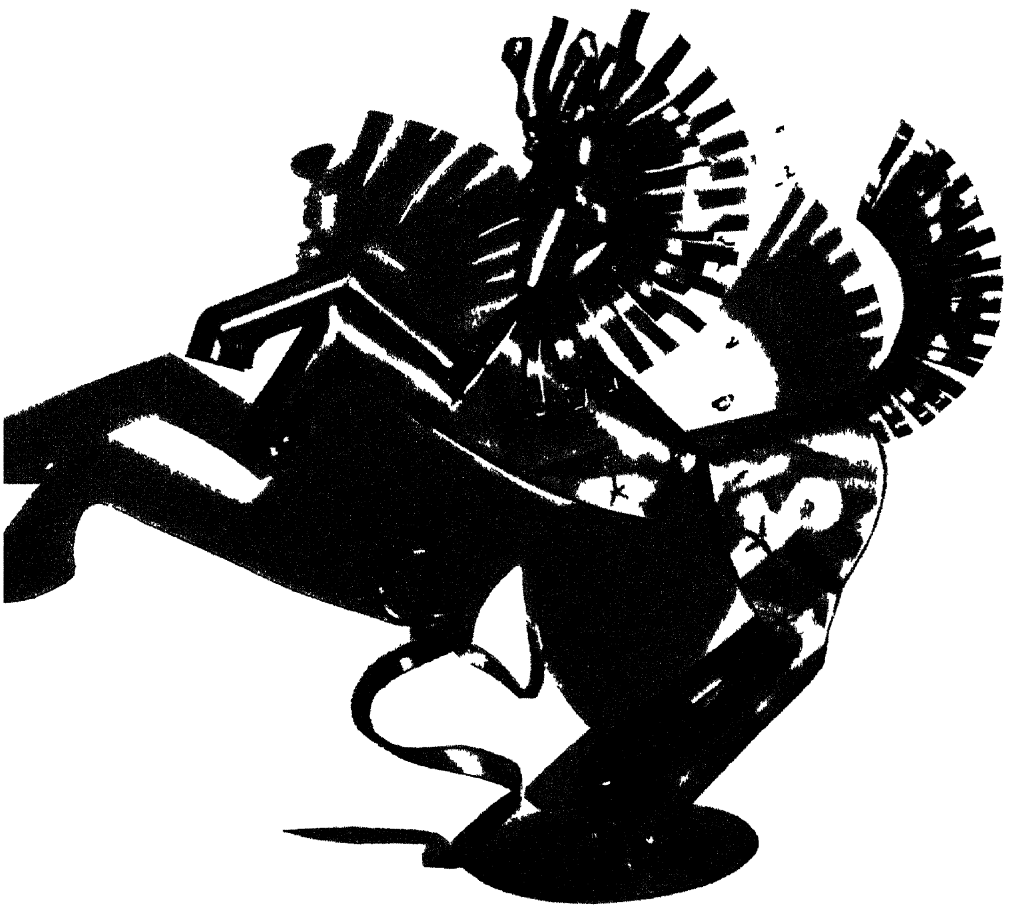
simple metalwork

how to do it

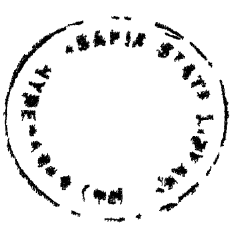
Levon West	1.	MAKING AN ETCHING
Clare Leighton	2.	WOOD-ENGRAVING AND WOODCUTS
George Pearse Ennis	3.	MAKING A WATER-COLOUR
Ashley Havinden (" Ashley ")	4.	LINE DRAWING FOR REPRODUCTION
Sargeant Jagger. A.R.A.	5.	MODELLING AND SCULPTURE IN THE MAKING
P. A. de Laszlo	6.	PAINTING A PORTRAIT
Walter de Sager	7.	MAKING POTTERY
Ansel Adams	8.	MAKING A PHOTOGRAPH
Molly Booker	9.	EMBROIDERY DESIGN
John Skeaping	10.	ANIMAL DRAWING
Stow Wengenroth	11.	MAKING A LITHOGRAPH
Iain Macnab	12.	FIGURE DRAWING
Duncan Miller	13.	INTERIOR DECORATING
Alex Strasser	14.	AMATEUR MOVIES AND HOW TO MAKE THEM
Anthony Hunt	15.	TEXTILE DESIGN
Bertram Nicholls	16.	PAINTING IN OILS
Alan Durst	17.	WOOD CARVING
Doris Zinkeisen	18.	DESIGNING FOR THE STAGE
Austin Cooper	19.	MAKING A POSTER
Clifford and Rosemary Ellis	20.	MODELLING FOR AMATEURS
Tommy Thompson	21.	THE SCRIPT LETTER
Lester Gaba	22.	SOAP CARVING
Kronquist and Pelikan	23.	SIMPLE METALWORK
Helen Coates	24.	WEAVING FOR AMATEURS
Walter Nurnberg	25.	THE SCIENCE AND TECHNIQUE OF ADVERTISING PHOTOGRAPHY
W. Suschitzky	26.	PHOTOGRAPHING CHILDREN
Edward Carrick	27.	DESIGNING FOR MOVING PICTURES
Minnie McLeish	28.	BEGINNINGS—TEACHING ART TO CHILDREN
W. Suschitzky	29.	PHOTOGRAPHING ANIMALS
Francis Marshall	30.	FASHION DRAWING
Percy V. Bradshaw	31.	I WISH I COULD DRAW
Dana Saintsbury Green	32.	MASKS AND PUPPETS
Vera Temple	33.	FLOWERS AND BUTTERFLIES
Mabel Early	34.	TOY-MAKING
C. F. Tunnicliffe	35.	BIRD PORTRAITURE
Percy V. Bradshaw	36.	I WISH I COULD PAINT
Russell Laker	37.	ANATOMY OF LETTERING

Other titles for the series in preparation



Simple METALWORK

By E. KRONQUIST
and A. G. PELIKAN



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contents

dedication

Gratefully dedicated to Dr. M. C. Potter and Dr. R. Cooley, Superintendent of the Public School of Milwaukee and Director of the Milwaukee Vocational School respectively, for the part their efforts have played in stimulating interest in the arts and crafts in each of their spheres.

acknowledgments

The Editor and Authors would like to thank all those who have helped in the preparation of this book, both by encouragement and advice and by the loan of photographs. Special thanks are due to the Victoria and Albert Museum, London, The Royal College of Arts, The London County Council Central School of Arts and Crafts, and The Worshipful Company of Goldsmiths for many of the examples of fine metalwork.

preface

The authors of this book are both craftsmen and teachers.

Mr. Kronquist was born in Sweden but trained in Copenhagen, where he served his apprenticeship as a silversmith and chaser in one of the now famous Danish silver shops. He later went to the U.S.A. where he became one of the pioneer teachers of industrial arts, and is now in charge of the Art Metal Department of the Milwaukee Vocational School. He is the author of the books *Metalcraft and Jewellery* and *Key to Mechanical Drawing Problems* and co-author of the text-book *Mechanical Drawing Problems* by Berg and Kronquist.

Mr. Pelikan is Director of Art Education in the Milwaukee Public Schools. He is a graduate of the Carnegie Institute and of Columbia University and was elected a fellow of the Royal Society of Arts in 1935. He is also an honorary member of the American national art fraternity "Delta Phi Delta." He represented the United States as Chairman of the American delegation to the International Art Congress at Brussels in 1935. He represented the United States also at the Congress in Paris in 1937. He was awarded the Journal purchase prize for painting in 1931, and in addition to writing for numerous art magazines, is the author of *Graphic Art Ideas*, *The Art of the Child*, etc.

introduction

In recent years there has been an ever-increasing interest in various forms of arts and crafts. This may be partly explained by the fact that many people have a desire to create something with their own hands, and partly because of the increase in leisure. Our lives have become so governed by the machine and its products that everything we touch is the result of machine production. Even our recreation has become mechanized so that we depend for amusement on the automobile we drive, the radio we listen to, or the motion picture performances which we attend. While all of these activities are admirable and have contributed to human happiness, there is the danger that large numbers of our people will lose the ability to use their hands for any creative or constructive effort. The excellent series of " How To Do It " books has done much to enable the amateur to practise the various arts and crafts by means of well-illustrated and simplified text-books which show the various steps required in the making of things from a piece of sculpture, a painting, or a photograph, to an embroidered panel. In each case the equipment and the problems have been so planned as to enable anyone who can follow simple directions to work out an unusual variety of useful and artistic objects.

Metal work has been looked on by the layman or amateur as beyond the reach of anyone but the trained professional craftsman. That this is not the case has been proved by the authors, who have worked with young people as well as with adults and have seen excellent examples of craftwork produced by both groups.

The examples produced and illustrated in this book include the work of amateurs. In some instances the objects shown have been made by students in the junior and senior high schools of the Public Schools and in the classes offered to men and women in the Vocational School of Milwaukee. Only those problems which can be made with comparatively simple tools have been selected and a sufficient variety included to offer a wide choice of selection.

In most instances the illustrations alone are sufficient to show the different steps involved in the making of an object, and the text has been limited to the minimum. Several well-known craftsmen have permitted the use of reproductions of some of their work. In each case the

emphasis has been placed firstly on good design, the elimination of unnecessary and elaborate ornamentation, an understanding of the limitations of the materials used, and secondly on a knowledge of the proper use of the tools and implements which are required to make the object.

The objects illustrated have been chosen because of their practical value and to demonstrate some of the various techniques which are important and which can be mastered easily. Many of the objects can be made with tools which may be secured for a reasonable amount from any hardware store and in each case only the most essential tools have been listed. It is a common belief of the uninitiated that metal is hard, unpliable, and difficult to handle, but anyone who attempts the first problems described in this book will be amazed at the ease with which many useful things may be made.

In a number of instances the original drawing, with general dimensions indicated, is shown, and with it the different parts needed, the progressive steps of construction, and the finished object. No problem has been included by the authors which has not been tried out by having both young people and adults follow the directions indicated for each problem. In this way unexpected difficulties on the part of the student have been brought to light and remedied accordingly.

An amazing number of attractive variations in design for each problem have been worked out by individuals and only lack of space prevents showing how each object may be redesigned according to personal taste. A number of good suggestions may be obtained by visiting the manufacturers of craft tools as some of these concerns publish very interesting illustrated pamphlets which not only illustrate a large number of craft tools but also designs of metal objects and processes of construction. Excellent examples of modern metal work are illustrated in the better-class magazines and these will serve as a source of material for those who may experience difficulty in creating their own designs without some means of reference to good examples.

American Art museums have done notable work in encouraging artist-craftsmen by holding annual exhibitions and offering substantial money awards. A surprising feature about these exhibitions has been (notably at the Milwaukee Art Institute) that some excellent work both from the point of craftsmanship and design has been created by amateurs, both men and women. Among these have been professional and business people as well as housewives who have found in this type of creative leisure activity an outlet for latent ability and a release from monotonous routine activities of everyday life.

the work shop

It is not a necessity to have an elaborate collection of tools to make things from various metals. Tools acquired as the need for them arises become the most useful. A table 30 inches high with a top of about 24 by 42 inches will suffice for the lighter type of work. Gas and water should be available, and the light good.

The tools shown in the photographs are only those used in the execution of each group of projects. The accumulated tools and equipment that have been used in the making of the objects throughout the book are listed below.

1 pair tinner's shears, 10 inches long
1 jeweller's saw frame, 5 inches deep
1 dozen jeweller's saw-blades, No. 2
1 hand drill
1 flat nose pliers, 4 inches
1 steel ruler
1 flat file, 8 inches second cut
1 half round file, 6 inches smooth
1 planishing hammer, 6 ounces
1 chasing hammer, 1 inch diam. face
1 ball-peen hammer
1 wood or rawhide mallet
1 iron stake
1 iron draw-plate, round holes
1 draw tongs
1 charcoal or asbestos block
1 polished planishing iron, about 3 x 3 x 1
1 bench vice of some kind

Tools for metalwork can be purchased anywhere. Jewellery supply houses, for example, generally carry a good assortment in this line.

Many kinds of metals are used by the craftsman and each has its own peculiarities and characteristics. The metals most extensively used are copper, brass, aluminum (or, as many prefer to call it—aluminium), pewter and silver.

Copper is easily worked. It ranks high among the softer metals. It is very tough, highly malleable, ductile and will take a good polish. The inexperienced craftworker need not be afraid of melting it when subjecting it to annealing in the process of making. The melting point of copper is nearly 2000° F. It is available in many shapes and forms, such as wires, bars, tubing, and sheets. It can be had hard, half-hard, or soft. Cold rolled and annealed copper sheet is best suited for craftwork because the surface is smooth and free of pits.

Brass is an alloy of copper and zinc. In varying proportions it is one of the most widely used metals in industry. It is harder to work than copper, being less malleable. Care must be taken in annealing brass because the melting point is considerably below that of copper. It is well also not to quench it while red hot. When copper is alloyed with tin, or tin and zinc, it is known as bronze and has more of a reddish

colour, brass being decidedly yellow.

Aluminum, the bluish-white metal, has become very popular with the craftworker. Next to oxygen and silicon, aluminum is the most widely distributed of all elements. It is easily worked and comparatively inexpensive owing to its light weight (about one-third that of copper). It can be obtained in many different forms and shapes and alloys from the metal dealers. For the average person, the term " soft aluminum " will suffice when buying material.

Good pewter metal is primarily a tin alloy. It is also known as Britannia metal, which may be said to mean an excellent grade of pewter. It is composed of 92 per cent tin, 6 per cent antimony, 2 per cent copper, and melts at about 500° F. Pure tin is so soft as to be unsuited for the making of articles for wear or use. The cheaper grade of pewter contains a considerable proportion of lead that imparts a dullness to the metal in a short time. Britannia metal is eminently serviceable and lends itself to a great variety of methods of metalcraft. Hard enough for everyday use, it has a subdued lustre and is slow to tarnish. There is a growing appreciation of pewter as a metal having a combination of qualities which mark it as a material for beautiful and useful articles for the home. Local dealers in metal usually carry a small stock of the popular gauges. The price is two or three times more than that of copper.

Silver is one of the most beautiful of metals : it is malleable, ductile and delightful to work with. Pure silver is too soft, but when alloyed with copper, it becomes harder and consequently more suitable for commercial purposes. Silver known as sterling is composed of 925 parts of fine silver and 75 parts of copper and it takes a brilliant polish. The cost of silver approximates, weight for weight, to the value of silver money.

Metal gauges. The metals commonly used by craftworkers are in the non-ferrous class (metals without iron). These are measured for thickness by an instrument called a gauge. It is a flat circular steel disc with numbered slots along the rim. The slot in which the metal fits is said to be the gauge of the metal. In America the non-ferrous metals are measured on the American Standard wire gauge, also known as the Brown and Sharpe gauge.

Preparation of metal. When purchasing material from the metal dealers it is well to insist upon getting metal that is cut clean and free from scratches and pits.

Clean the metals, copper, brass, pewter, and aluminum, by scrubbing vigorously with fine pumice powder and water. If any blemishes are

present they should be removed by a scraper, burnisher and fine emery cloth. Silver is prepared for work by making it red hot (annealing) then leaving it in a pickling acid for from five to ten minutes after which it will become pure white. Pickling acid is made by adding six to eight ounces of sulphuric acid to about one gallon of cold water.

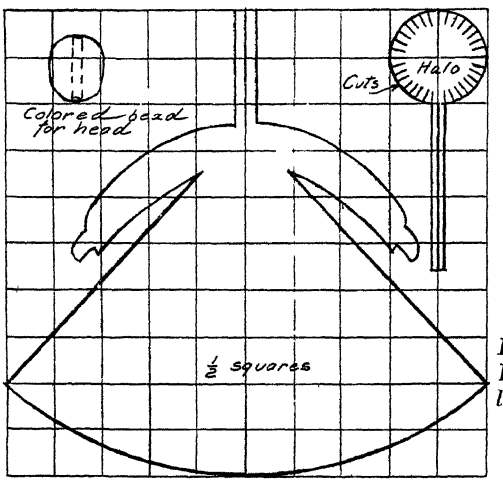


Fig. 2.
Pattern for cut-out design of angels. Make of light gauge metal—aluminium, copper or brass

design

The design of the project to be made is, of course, important, but it is best for a beginner to copy a simple project until he becomes acquainted with the tools and gets the " feel " of different metals.

Cut-outs from thin gauge metal are the easiest to make, such as the angels shown in *Figures* 2-3-4-5-6-7. These make attractive table decorations or place-cards. The Dachshund, *Figures* 8-9, may be used as a cigarette holder. Thin gauge metals, number 24 or 26, can be cut with an ordinary pair of scissors and bent with the fingers.

Pierced work with a jeweller's saw, such as simple jewellery, clips, two initials for a bag, or house numbers. should be made from heavier gauge metals, numbers 18 to 22.

Hammered bowls of the shallow types, *Figure* 10, can be made in a variety of shapes with very little equipment and afford good practice in using hammer and mallet, which is essential to good metal craftsmanship.

Construction work, where several pieces have to be made and assembled, requires more skill and experience and additional equipment. The making of a simple box, *Figure* 11, usually requires lay-out, scoring, bending, hard or soft soldering, hinge making, filing, and fitting.

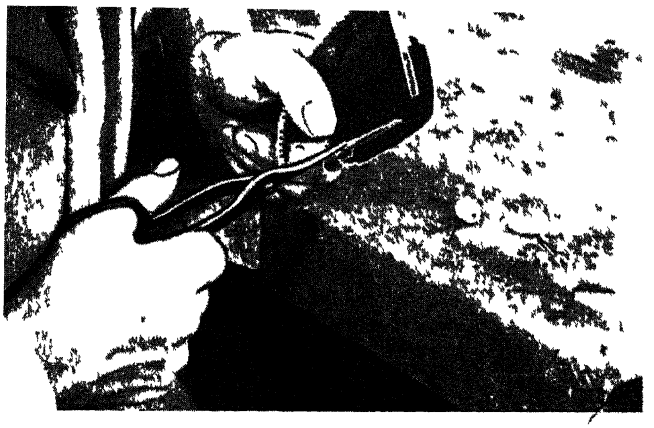


Fig. 3

Light gauge metal may be cut with an ordinary pair of scissors

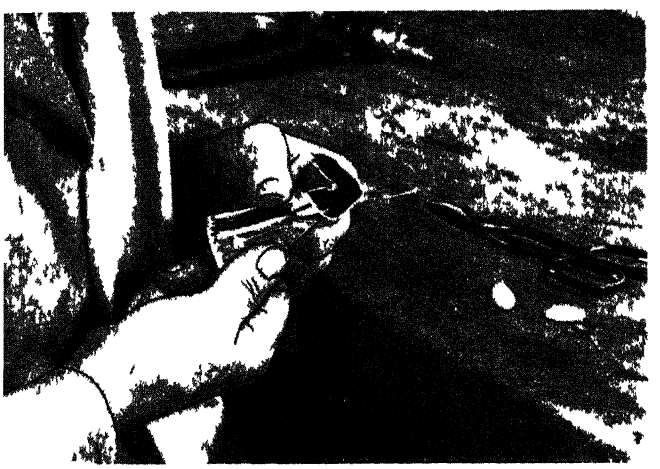


Fig. 4

Light gauge metal can be bent or formed with the fingers. Sharper bends will require flat and round-nosed pliers

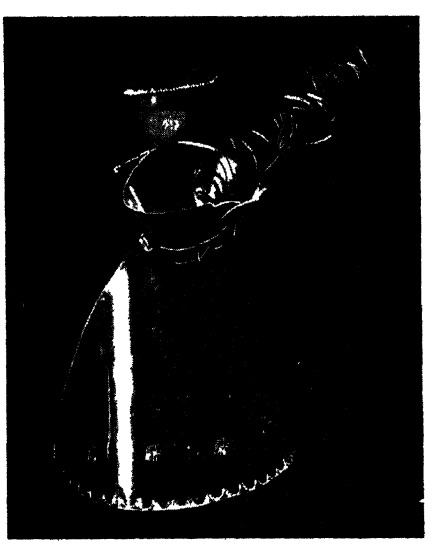
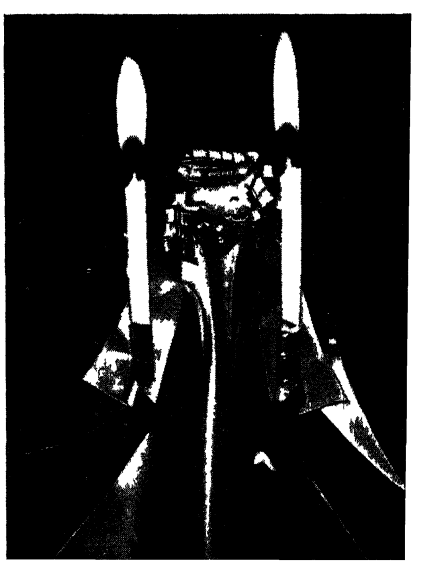


Fig. 5.

Cut-out figures which can be used as table decorations, place-cards, flower and candle holders.

Figs 6 *and* 7



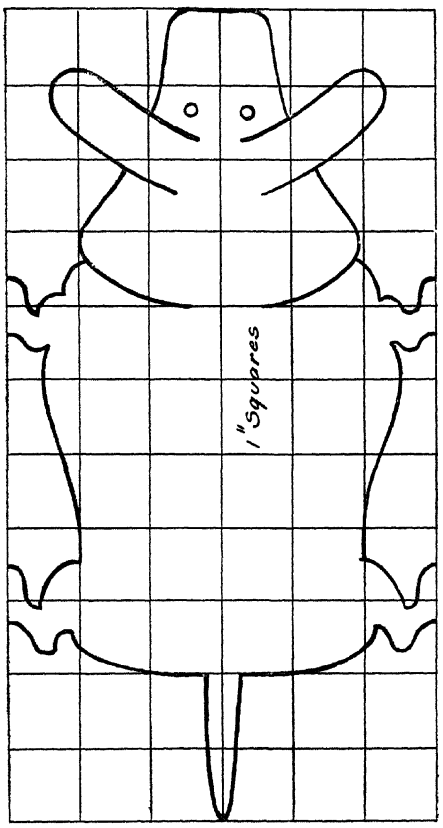


Fig 8
Lay-out pattern for dachshund Aluminium, copper or brass—No 24 guage metal B & S gauge

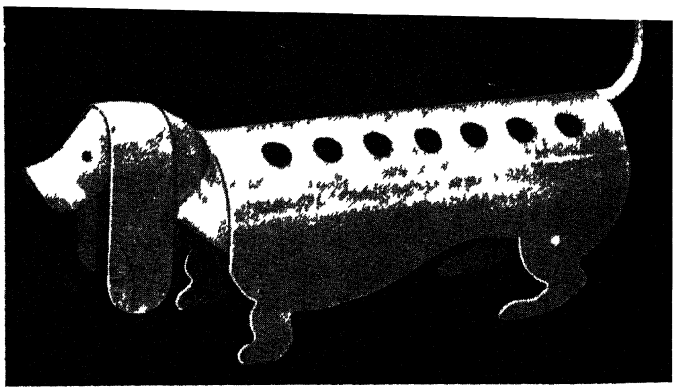


Fig 9 Dachshund cigarette holder.

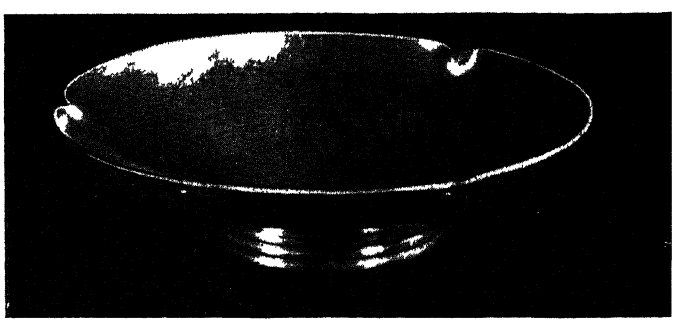
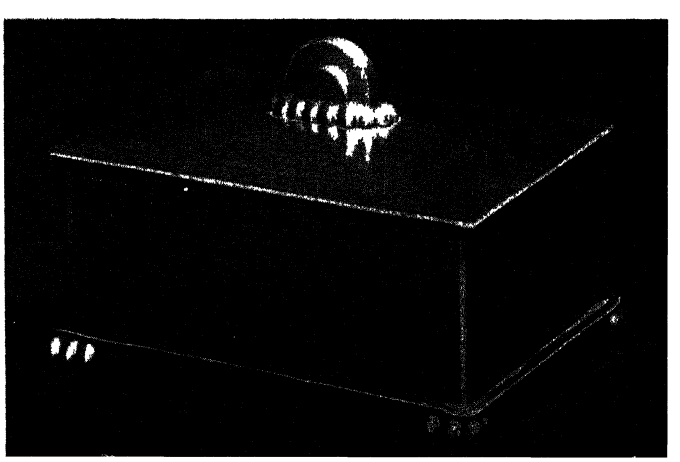


Fig 10 A shallow candy bowl.

Fig 11 Pewter box for cigarettes, trinkets or cards



Metal cutting shears are made in many shapes and sizes, also right and left handed. A pair of ten-inch shears known as tinner's snips will answer the purpose for most work, *Figure* 12.

The jeweller's saw is one of the most useful of tools to a craftworker. It is inexpensive and may be had in many depths (the depth is the distance from the saw-blade to the back of the frame). A five-inch saw is a good all-round tool. The saw blades are sold in dozen or gross lots, and made specially for cutting metal. They can be had in many sizes, the finest approximating to the thickness of a hair, but a number 2 saw is most useful, *Figure* 13. The saw is used in a vertical position as a rule,

Fig. 12.
Cutting metal with a pair of tinner's snips.

Fig. 13.
Using a jeweller's saw. Most sawing is done with the saw in a vertical position.

Fig. 14.

Setting a new blade in the saw frame. Always use a light pair of pliers to tighten the screw that holds the saw in place.

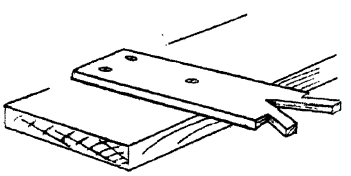


Fig. 15.

V-shaped cutting board for convenience when sawing.

and the cutting is done on the down stroke. In clamping a new blade into the frame care should be taken to have the teeth of the saw pointing toward the handle of the frame, *Figure* 14. Spring the frame so as to get a fairly good tension on the blade. A loose or sloppy saw breaks easily and cuts inaccurately. For convenience of working it is well to make from a piece of wood a V-shaped cutting board, *Figure* 15, that can be clamped or nailed on to the work table.

The *hack-saw* is used for cutting heavy gauge metal. It is always used in a horizontal position with the material held in the vice for the sake of rigidity. The teeth of the saw should point away from the handle so that the sawing is done on the push stroke. The saw must be held firmly with both hands, as a sudden jar would break or snap

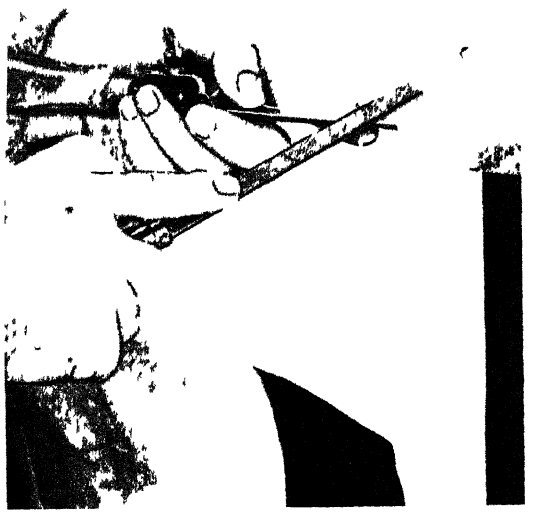


Fig. 16.
Filing is always done on the push stroke.

Fig. 17.
The hand-drill must be held firm and steady.

the blade. A ten-inch saw having 32 teeth to the inch is suitable for most of the non-ferrous metals.

Files are made in numerous shapes, sizes, and cuts. The following are recommended : 8 inch flat second cut ; 6 inch flat-smooth ; 8 inch half round second cut ; 6 inch half round smooth ; 6 inch round second cut ; and 6 inch triangular smooth. A file is a cutting tool with sharp teeth all pointing towards the top of the file ; consequently the actual filing is performed on the push stroke, *Figure* 16. If a file becomes clogged with metal particles, it can be cleaned with a wire brush or a small scrap of metal drawn across the teeth. Some metals, such as copper, brass and pewter, can be removed by dipping the file in nitric acid.

A hand drill with an assortment of half a dozen twist drills of the smaller sizes should be sufficient. A hole cannot be drilled in a piece of metal without first indenting the metal with a punch and small hammer, a nail making a good punch. The hand drill must be held firmly as shown in *Figure* 17. Any sudden jar may result in breaking the drill, especially if it is of the smaller kind.

annealing and pickling

Annealing is the subjecting of metals to high heat for the purpose of softening them. It removes the strains that have been induced into the material by any previous treatment. All metals become dull red when they have reached a temperature of about 800 degrees F., consequently metals, such as tin, lead, and zinc, that melt around 500 and 600 degrees cannot be annealed. There are many ways in which a piece of metal can be annealed. The gas and air torch, *Figure* 18, is the most efficient, but a good job of annealing can be done on an ordinary gas plate or Bunsen burner. Small pieces of metal should be annealed with the mouth blowpipe, the work being placed on a charcoal or asbestos block, *Figure* 19.

In the process of heating, an oxide is produced on the metal. On some metals the oxide is visible and on others it is not. After a metal has been made red hot, it should be dropped into a pickling solution (six or eight ounces of sulphuric acid added to one gallon of cold water) for cleaning, after which it should be rinsed with water. The bluish-black scale formed on copper in annealing is readily dissolved in the acid and leaves the copper clean, pink and pleasant to work with.

Fig. 18.

Annealing with a gas torch. Annealing is necessary in order to reduce the hardness of the metal and to render it more workable.

Fig. 19.
Annealing a small piece of metal on a charcoal block using a mouth blow pipe and an alcohol lamp The same method is used for soldering.

Sterling silver becomes pure white after annealing and subsequent pickling.

Small work may be boiled in the acid solution provided a copper, brass, lead, or porcelain container is used. All iron must be kept away from silver while it is being pickled as it leaves a red deposit on the surface of the metal. The pickling solution dissolves the extracted deposit of oxide formed in the process of heating and leaves a coating of fine silver on the surface which in turn is scoured with a fine abrasive or a fine wire scratch-brush.

aluminum *or, if you will, aluminium!*

Great care must be exercised in softening or annealing aluminum because it melts around 1200° F. and being a white metal. it is difficult to see when it is dull red at about 800° F. To guard against melting the metal, touch it occasionally with a stick of wood or the end of a match ; when the wood shows signs of being scorched and leaves a black streak on the metal the temperature is between 700 and 800 degrees. Do not pick up the aluminum while red hot as it is very brittle when in that

state. Let it cool somewhat before quenching it in water. Aluminum should not be put into the sulphuric acid pickling bath.

Without annealing, a metal object would never arrive at the final stage desired, but would fracture or crack from the hardness brought about by the strains and extensions of the molecular re-arrangement of its structure.

The pickling of metals is also an essential part of the work of the craftsman. It would be difficult to see any of the blows of the hammer or do any kind of marking on the surface of the metal if the oxide were not removed. Scrubbing with an abrasive such as cleanser or pumice would take too long and not accomplish what acid does in a couple of minutes.

soft soldering

Soldering is divided in two classes—hard and soft soldering. *Soft soldering* is the name given to a process of uniting metal parts by means of fire and the use of a third metal, the solder, when only a low degree of heat can be applied to the work. The process is commonly known as tin soldering. The solder is a combination or alloy of lead and tin; 50 per cent of each is the most common, and is known as half-and-half solder. Special low melting solder is made by adding bismuth and cadmium. Solder in wire form is the handiest. Metal members to be united must be clean and free from oxides and irregularities and they must fit together. Oxidization of the metal must be guarded against during the soldering process and for this reason it is necessary to employ a flux to promote the fusion of the metal.

Zinc chloride (muriatic acid with zinc added) is the best flux to use on copper and brass but prepared soldering salt may be purchased in any hardware store and is much more convenient to handle.

Method

1. Apply the flux to the joint with a small brush.
2. Heat the work by holding over a flame, Bunsen burner, or torch, until the flex boils and crystallizes.
3. Apply the flux a second time.
4. Heat the work again.
5. Withdraw the work from the flame quickly and touch the joint with a piece of wire solder.

It is very important to be well-prepared and to do the soldering quickly, because oxides form rapidly in the process of heating and solder does not flow on an oxidized joint. If the solder does not run, it is most likely due to oxidization of the metal, in which case apply more flux. It may also be due to insufficient heating.

Soldering with *the bit* is rarely employed in art metal work, but there are occasions when it has to be done.

Method

1. Apply the flux to the joint with a small brush.
2. Heat the soldering copper in a gas furnace or over a gas plate.
3. When hot, dip the point of the bit in the flux.
4. Apply a little solder to the point of the bit (if the bit is clean and hot enough a blob of solder will adhere).
5. Apply the hot bit to the joint, moving it slowly along the joint. *Figure* 20.

Careful preparation, well-fitted joints, quick application of heat, and generous use of the flux are essential for a good job.

Fig 20.
Soft soldering. One way of using the soldering capper (bit)

Fig. 21.
Soft soldering, using wire solder and a Bunsen burner The zinc chloride flux is within easy reach.

fusing, welding or soldering pewter

Method

1. Fit and clean the joint with scraper, steel wool, or fine emery cloth.
2. Wrap a piece of cloth around a stick of wood and fasten it in the bench vice in a horizontal position.
3. Hang the work on the stick.
4. Swab the joint with the flux.
5. Place small pieces of *pewter*, not solder, along the joint.
6. Heat and clean the soldering bit by dipping the point in the flux and wiping it with rag.
7. Apply the hot bit to the joint, moving it slowly so as to fuse the small pieces of pewter with the work.
8. Rinse in water.
9. File and scrape away any surplus metal.

Welding pewter can be done with a mouth blowpipe, but it is more difficult.

An extra easy-flowing soft solder can be made by melting 50-50 solder in one ladle and adding 25 per cent of its weight of bismuth to it. This solder is particularly useful when ornaments have to be applied to work with previously soldered joints.

Pewter may be soldered or fused into a permanent union but great care must be exercised in the application of the heat because of the low melting temperature of the metal. Acid fluxes should be avoided. They may pit the surface of the metal.

The *flux for pewter* is made by adding to one ounce of glycerine 10 drops of hydrochloric acid.

Method

1. Apply the flux to the joint with a small brush.
2. Have ready small pieces of wire solder, 50-50, of sizes to suit the job.
3. Pick the pieces of solder up with a pair of tweezers and place them along the joint.
4. Hold the work over the flame of a Bunsen burner, moving it slowly back and forth, and watch closely for the solder to melt.

The solder will " run " shortly after the flux boils. Since there is very little difference in the melting point of the solder and the pewter, the work must be removed from the flame at once.

hard soldering

Fig. 22
Hard soldering — applying the heat with a gas torch and watching for the silver solder to "run"

Hard soldering or brazing always requires a high degree of heat. Silver alloyed with copper and zinc in various proportions is the medium used. " Hard flowing silver solder " is a name given to silver solder that has a small percentage of zinc added and flows at a higher temperature than " easy flowing silver solder" which has a larger percentage of zinc added to its alloy. Silver solder is used in wire or sheet form depending upon the work on hand.

Borax is always used as a flux for hard soldering. The borax solution is prepared by dipping the lump of borax in water and grinding it on a piece of slate in a rotary direction until a milky solution is produced.

Method

1. Cut small pieces of silver solder of the desired size with a pair of snips and place them on the edge of the borax plate.
2. With a small brush apply the borax solution to the joint prepared for soldering.
3. Evaporate the water from the borax by holding the work over a clean blue flame. When the water has evaporated a thin white coating of borax has been deposited on the work.
4. With the tweezers pick up the tiny pieces of silver solder, dip them in borax, and place them one by one on the joint to be soldered.

5. Place the work on the coke or charcoal, being sure it is in a level position. Silver solder flows like water when in a molten stage.
6. Heat up the entire piece of work rather gently at first, then concentrate the flame on the joint, keeping a sharp eye on the solder, watching for it to " run." *Figure* 22.
7. Let the work cool somewhat, then remove any iron wires or clips that may have been used in holding the joint or pieces together while soldering.
8. Place the work in the sulphuric acid pickling solution (to a gallon of cold water add 6 or 8 ounces of sulphuric acid) for the purpose of dissolving the oxide and the fused borax. The borax forms a protective glaze on the work while being heated. This borax glaze cannot be scraped or rubbed off.

In hard soldering the work is always brought to a bright red heat and the success of a good job depends upon a well-prepared joint and a quick application of the heat. Only metals in the higher bracket of melting temperatures can be " hard soldered " such as silver, copper, brass, or bronze. Aluminum cannot be hard soldered. Never attempt to hard solder where tin or lead exists in any form.

surface and edge treatment

Planishing is the process of hammering a metal surface smooth, or of giving the metal a surface texture. It requires a good deal of practice. Often the process is repeated many times before all blemishes and bruises from previous hammering have disappeared. Only tools with a mirror polish should be used. The blows of the planishing hammer should fall close to each other, and the work be held in such position on the anvil or stake that the metal is struck only where it is in contact with the stake. The blow of the hammer should have a solid ring to it ; a hollow sound would indicate that the work is not in the right position or that proper co-ordination between the right and left-hand operations has not yet been acquired. Uniform weight of blows is obtained by keeping the upper arm close to the body and using a wrist motion in hammering.

Method 1. Select a stake that has a shape or contour like the work to be planished.

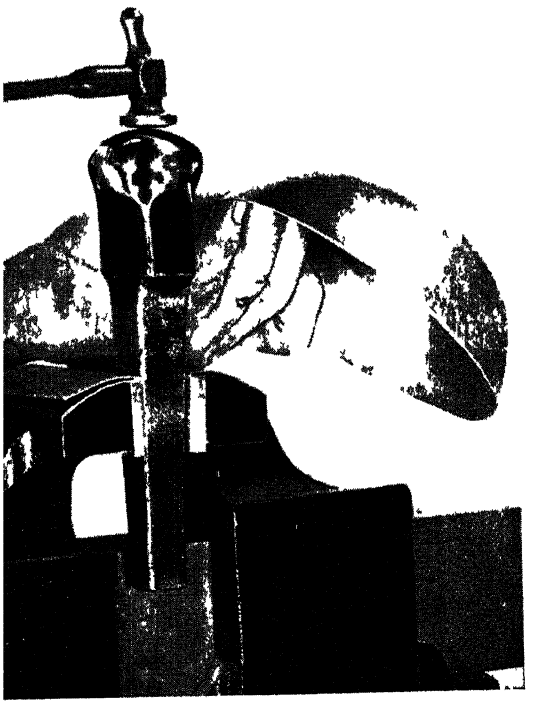


Fig. 23.
Planishing. Where the blow of the hammer should fall—directly above the stake.

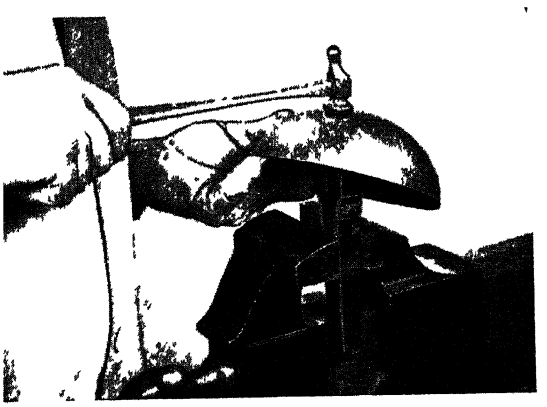


Fig. 24.
Planishing a bowl on an iron stake.

Fig. 25.
Finishing an edge by dividing it into units.

Fig. 26.
Hammering an edge on a plate using a steel punch.

2. Select a planishing hammer of suitable weight and shape.
3. Secure or fasten the stake in the bench vice.
4. Stand firmly and find the position where the blow of the hammer should be delivered. *Figure* 23.
5. Place the work on the stake or anvil holding it firmly but lightly.
6. Commence the planishing, striking all the blows so that they fall evenly over the same place on the stake, at the same time revolving the work so that no two blows are delivered to the same place and no space left between the hammer marks.

The work should be clean and free from grease and oxide so that each blow of the hammer is clearly visible.

When iron stakes are not available to fit the shape of the work, chaser's pitch can be used. A good composition of this all-important pitch is made by melting in a kettle one pound of black shoemaker's pitch and one quarter of a pint of rosin, and stirring in one and a half pounds of plaster of paris. This pitch composition can be re-melted and used over and over again ; when it is cool it is hard and firm and still tough enough to withstand the blows of the hammer.

The edges of metal may be finished in a number of different ways. First, it is important to finish the raw edge by filing and scraping and then using fine emery cloth. Steel punches of various shapes and sizes will put attractive finishing touches to art metal objects, *Figures* 25 *and* 26. A variety of inexpensive borders may be purchased by the yard or pound and applied to the work by soldering, *Figures* 27 *and* 28.

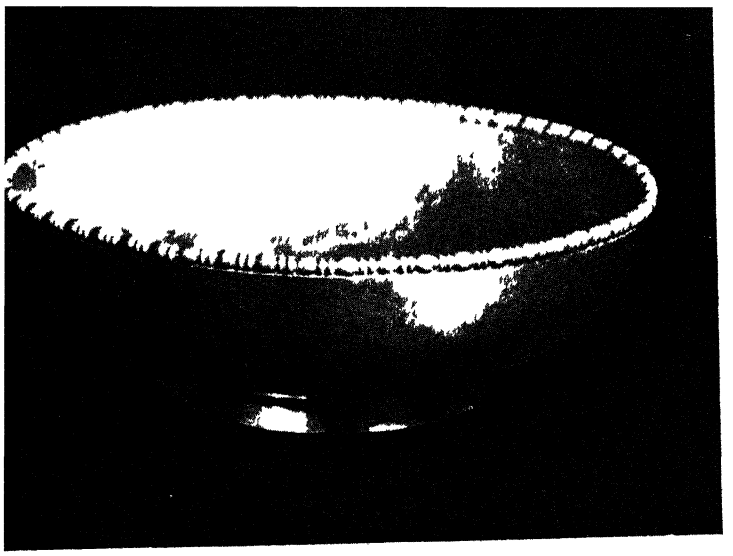


Fig. 27.
A hammered bowl trimmed with a beaded border.

polishing

In polishing a piece of metal it is necessary to have powder and wheels of different kinds. Selection of proper polishing wheels and the correct composition for use depends largely upon the class of metal that is to be polished. The compound used is a tripoli composition (a decomposed silica) with a grease binder, and after that a rouge of some kind is needed. Polishing by hand would take a good deal of hard rubbing to get anything like a high polish on a piece of metal.

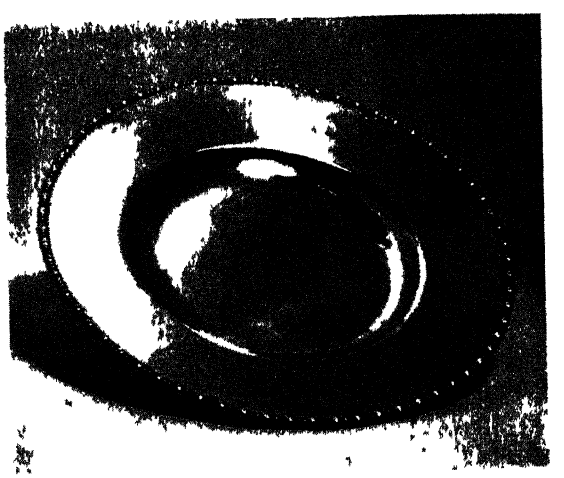


Fig. 28.
Border applied to a plate by soldering.

colouring or oxidizing

Colouring or oxidizing of a metal object is necessary in many instances to bring out the beauty of workmanship. Many chemical compounds are used to produce different effects, but the most common is a sulphur compound. Liver of sulphur is easy to use and easy to control. Ammonium sulphide is practically the same thing only this is in a

liquid form while the former is solid. The following procedure will always give good results :

Method

1. Prepare the oxidizing solution by dissolving a piece of Liver of Sulphur about the size of a large pea in one gallon of warm water. Suspend the work in the solution, moving it constantly until a deep brown or bluish-black colour appears ; remove and rinse in water.
2. Scrub the work with a small brush using water and fine pumice powder ; a kitchen cleanser is good too.
3. Scrub it again with pumice or cleanser and water, avoiding touching the surface of the metal with the fingers.
4. Dip it again as before and rinse it in hot water. The second dip always produces a better colour than the first dip.
5. Dry the work thoroughly.
6. Rub the high spots of the work (high-light) with 0000 steel wool.
7. Apply a coat of furniture wax and let it dry for about 15 minutes, then polish with soft clean rag.

N.B.—This solution stains the fingers. Use some kind of a wire or stick of wood while dipping the work for oxidization.

Pewter is finished and given a beautiful velvet-like lustre by (1) vigorous scrubbing or rubbing with extra fine pumice powder and water; (2) rinsing in running water to remove all pumice powder : and (3) rubbing it thoroughly with 0000 steel wool and white laundry soap.

wire drawing

Often it becomes necessary to reduce the size of a wire or make a piece of tubing for a hinge. The tools used for this purpose are called draw-plate and draw-tongs, *Figure* 29. The draw-plate is a common tool of the metalcraft worker—a steel plate with a succession of progressively smaller holes. The wire to be reduced in size is pulled through the holes one after another, annealing it from time to time. File one end of the wire to a long taper so that it can be gripped well with the draw-tongs.

A piece of metal tubing can be made in the following way :

1. Cut a strip of light gauge metal, number 24, the width of which should be approximately three times the diameter of the required tube.

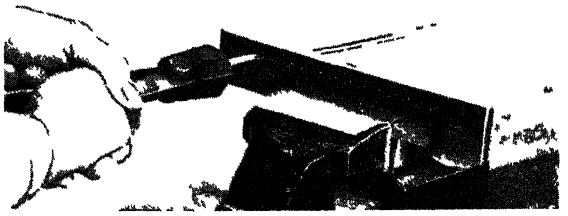


Fig. 29.

Drawing wire to a smaller size or making a piece of tubing Tools used are the draw-plate and draw-tongs.

Fig. 30.

Cutting a taper to one end of a strip of metal preparatory to the making of a piece of tubing.

2. Cut one end of the strip to a long taper, *Figure* 30.
3. With a raising hammer and a grooved block of wood, hammer the strip of metal into the shape of a gutter, *Figure* 31.
4. Fasten the draw-plates in the vice and pull the strip through the holes one after the other. Gradually the strip of metal will be formed to a tube.

Tubing can also be made over a steel wire by hammering the strip of metal over the wire in the grooved block of wood until the edges meet, then pulling it through the holes in the draw-plate. Anneal it occasionally and lubricate it with a drop of oil. The wire is pulled out of the tube by reversing the draw plate in the vice and drawing it through a hole in the plate the size of the wire, not the size of the tubing.

Links for chain are made by winding the wire around a mandrel of the desired shape of the link, then cutting the spiral so formed with a jeweller's saw, thus separating it into links.

Fig. 31.

Beginning to make a metal tube. Hammering a strip of metal into a grooved block of wood to make it U-shaped

HOW TO DO IT

useful objects you can make

The following pages have been planned to show " how to do it," step by step. A few problems, which involve the various processes explained so far, have been chosen and illustrated with photographs and instructions, which should enable anyone with little or no training to make the articles described.

All of the examples illustrated embody the elementary processes in metalcraft and have been included because, with the experience gained in making any of these objects, many other varied objects which embody these same principles may be worked out.

For the beginner it is quite permissible to copy any of these articles while learning. There is always sufficient opportunity to make variations according to individual needs and preferences. It is indeed advisable to have access to good reference material, such as is shown in the Appendix, in order that the design of the object to be made follows the dictates of good functional design which is the foundation underlying all good work. No amount of skill and craftsmanship will ever compensate for a poor or ugly design. The two should go hand in hand and it should further be recognized that skill in any craft, as well as appreciation of good form and design, are acquired only by diligent practice and application.

making a hammered bowl

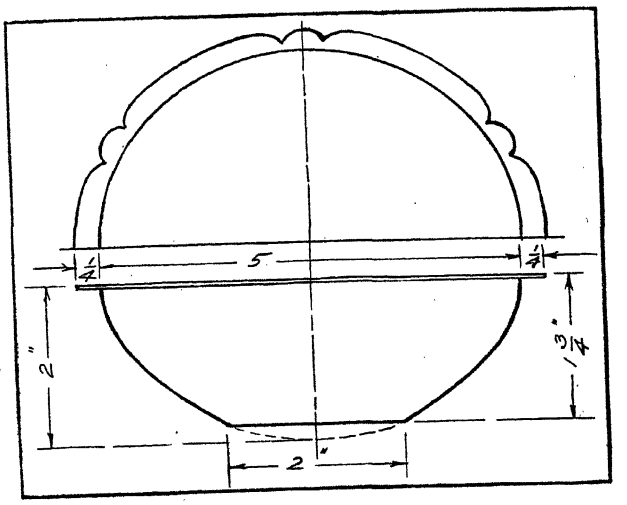


Fig. 32.
Working drawing of simple copper bowl.

The making of a hammered copper bowl, *Figure* 32, has been selected as a typical project for a beginner. The object is to hammer and stretch a metal disc to the rough shape of a bowl—the usual preliminary to any regular forming and shaping. By *stretching* is meant the hammering of a metal disc with a hammer which has one or two of its faces shaped round or ball-like. It is the starting operation in nearly all projects in art metal work classified as Hollow Ware.

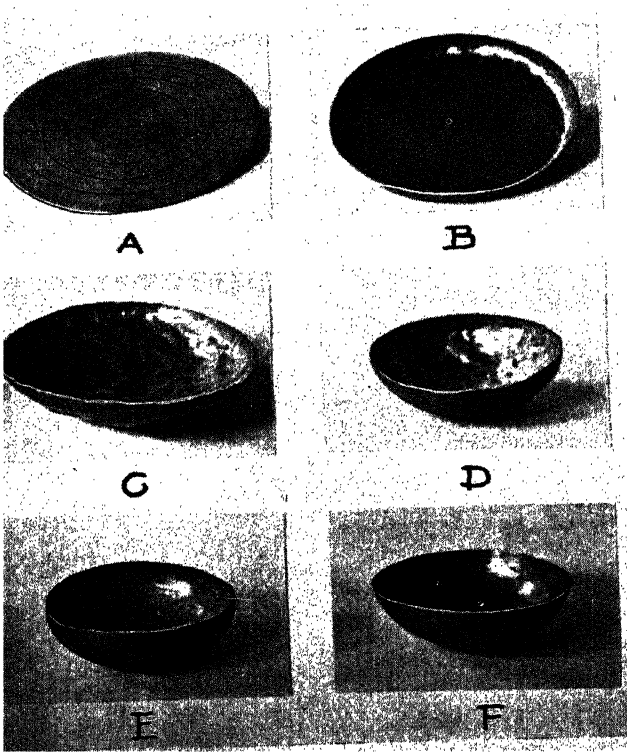


Fig. 33.
The progressive steps in hammering up a bowl from a flat piece of metal.

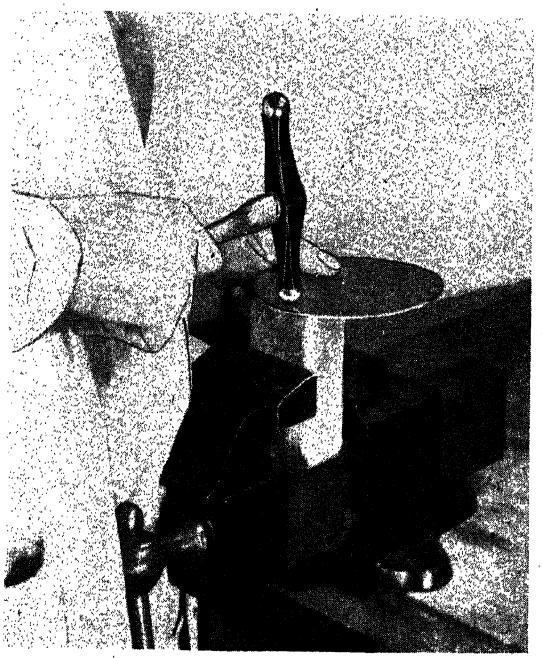


Fig. 34.

Starting a bowl. The metal is hammered into a slightly hollowed wood block with the ball-peen hammer.

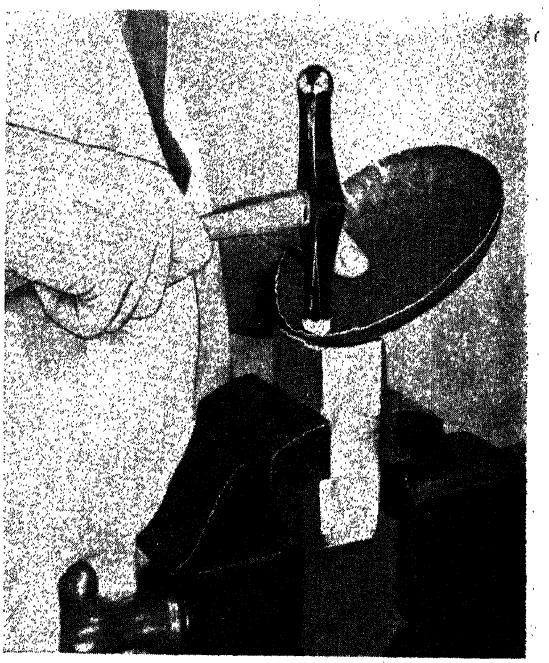


Fig. 35.

Starting the second beating along the outer edge after the annealing of the metal.

Method

1. Use a six-inch square piece of soft cold rolled copper No. 20 gauge.
2. Draw with a pencil two diagonals to locate the centre of the square.
3. Mark the centre lightly with a centre punch and a small hammer.
4. Describe a six-inch circle with a pair of dividers.
5. Cut the metal to a circular disc using a pair of shears.
6. Draw a series of concentric circles about one-half inch apart on the metal disc with a pencil compass—note A in *Figure* 33. These lines are used as a guide in hammering.
7. Place a piece of hardwood, about 2 in. by 3 in. by 5 in. in the bench vice, with the grain end up.
8. Hammer or gouge out a shallow cavity into the end grain of the wood.
9. Lay the metal disc on the top of the cavity in the wood block so that the edge of the metal lies across the depression in the wood. *Figure* 34.

10. Select a ball-peen hammer of the type shown in the photograph. Start hammering the metal into the cavity along the outer circle, but avoid striking the edge of the metal. The blow of the hammer should be uniform in weight to avoid any lopsidedness. After the first round of hammering the metal disc will have the appearance of B in *Figure* 33. Continue hammering in a circular fashion, following each concentric circle until the centre of the disc has been reached and the metal has taken the shape shown in C, *Figure* 33.
11. Anneal the metal. The metal disc which has now taken the shape of a shallow bowl has also become very hard from the beating. In order to make the metal soft again it must be annealed and made red hot. (See chapter on annealing—page 30).

Fig. 36.
The metal disc is taking a deeper shape as the hammering progresses.

Fig. 37.
Beating out the many irregularities caused by the ball-peen hammering.

12. Throw the hot metal disc into the pickling solution (sulphuric acid and water, see chapter on pickling—page 21) to dissolve the oxide formed in the process of heating and incidentally to clean the metal and make it more pleasant to work with.
13. Rinse the work in running water.
14. Restore the circular guide lines with a pencil compass.
15. Start hammering right inside the edge of the metal, *Figure* 35, and continue round and round until the centre has been reached, *Figure* 36.
16. Anneal and pickle the metal again. The work will now look like D in *Figure* 33.
17. Repeat the hammering, and the metal bowl has now reached a height of about two and a half inches.
18. Fasten an iron stake in the vice, place the work on the stake and beat out the irregularities with a raw-hide, or wooden mallet, *Figure* 37.
19. Anneal and pickle the metal again, then scour it with pumice powder and water, rinse and dry. This is preparatory to the finishing process.
20. Draw a few light pencil circles on the outside of the bowl ; place the work on the stake as shown in *Figure* 38. Select a hammer and start planishing in the centre, covering one area at a time. The blow of hammer should fall squarely on the work where it has contact with the stake, each blow of the planishing hammer slightly overlapping the preceding one. It is all-important that the hammer and stake are free from scratches and blemishes —in fact highly polished tools should be the pride of the craftworker. Rubbing the face of the hammer on crocus cloth will produce a mirror finish.
21. Place the bowl on a table as shown in *Figure* 39. Mark off the irregular parts with a surface gauge, or a pencil held firmly will do.
22. Clip with a pair of snips any excess metal, so that the bowl is " level," *Figure* 40.
23. Gauge a line one quarter of an inch from the edge on the inside of bowl, using a pair of dividers or compass, *Figure* 41.

Fig. 38.
Planishing puts the finishing touch to the metal surface.

Fig. 39.
Using a surface gauge for marking.

Fig. 40.
Chipping off the excess metal to level the work.

24. Place the work against the sharp edge of an iron as shown in *Figure* 42. Use the round end of a mallet and turn the edge of the metal by gentle hammering, *Figure* 43. Finish by using the flat side of the mallet, *Figure* 44.
25. Divide and mark the edge into a unit design and file to shape, see *Figure* 32. Finish with emery cloth.
26. Flatten the bottom by placing the bowl on a round piece of steel two inches in diameter, hammering it flat with a wood mallet.

Fig. 41.
Gauging a line with a pair of dividers.

Fig. 42.
Placing the work against the iron, preparatory to the turning of the metal.

The finished bowl can be left in the natural bright copper colour and waxed, or oxidized, high-lighted, and waxed. When a bowl like this is made in pewter the operations are the same with this exception—pewter cannot be annealed. However, in this case it is not necessary. A pewter bowl should be finished with fine pumice powder and water, after which it is rubbed with 0000 steel wool and a white soap and water.

Fig 13.
Starting hammering the edge of metal

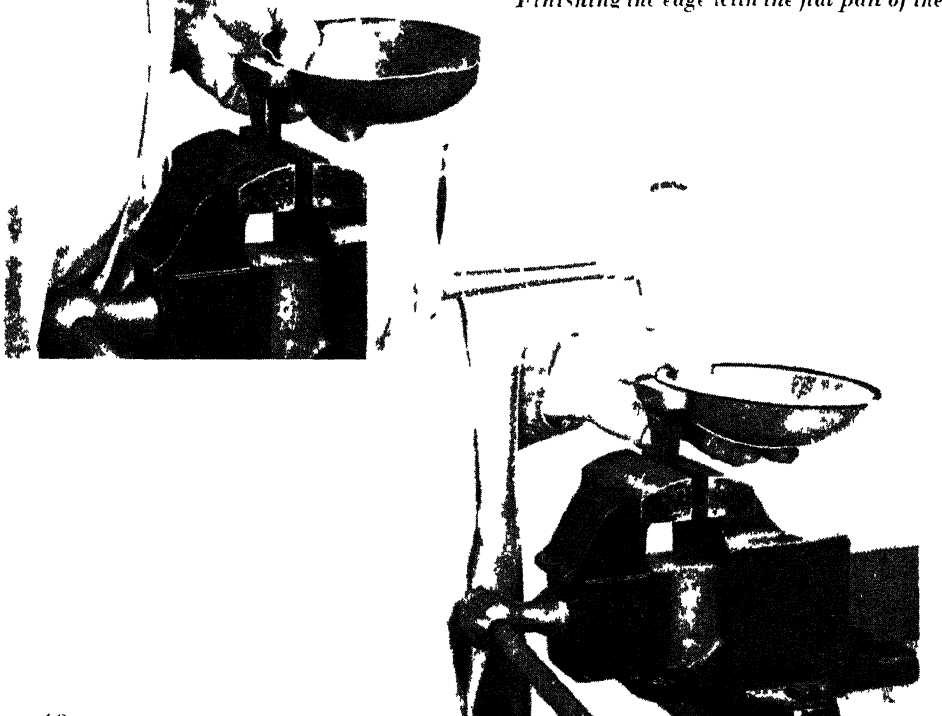
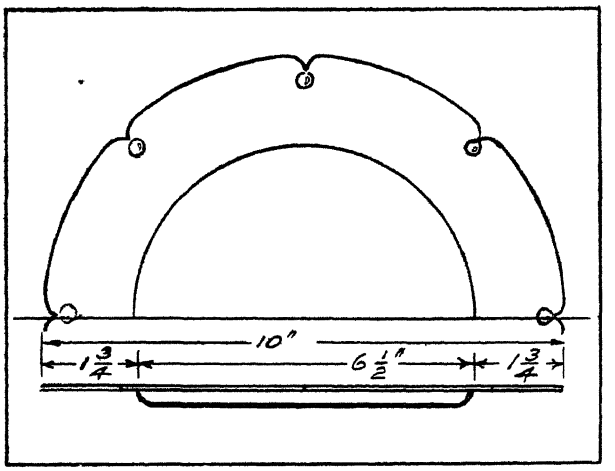


Fig 14
Finishing the edge with the flat pan of the mallet



making a plate or tray

The making of a plate or tray, where a well has to be sunk or hammered into the metal, requires but little equipment. *Figure* 45 shows a round plate ten inches in diameter with a well six and a half inches in diameter.

Method

1. Select a ten-inch square of cold rolled soft copper—number 18 gauge.
2. Scrub the metal with pumice powder and water, then dry.
3. Draw with a pencil diagonal lines to locate the centre of the square.
4. With a small hammer and a punch lightly mark the centre.
5. Describe a ten-inch circle with a pair of dividers.
6. Cut to line with pair of shears.
7. File the edge if necessary.
8. Planish the entire circular disc.
9. Anneal and pickle the metal disc.
10. Straighten the metal with wood or raw-hide mallet.
11. Describe the inner circle with the dividers, $6\frac{1}{2}$ inches.
12. Select a piece of hardwood, about 2 by 3 by 5 inches, and fasten it in the vice with the end grain up.
13. Hold the plate on the end of the block of wood and draw a pencil line along the circumference so that two nails may be placed as guide pins for sinking the well of the plate.

14. Place the metal disc against the two pins and begin hammering. The work should be rotated slowly so that the well is sunk evenly all the way round, *Figure* 46. The position of the worker should be firm, with the arm against the body, and a wrist motion used in delivering the blows. The tool used is an oval-faced hammer called a tray hammer. One face of the hammer is a narrow, rather long oval, the opposite is broader and more convenient for finishing.

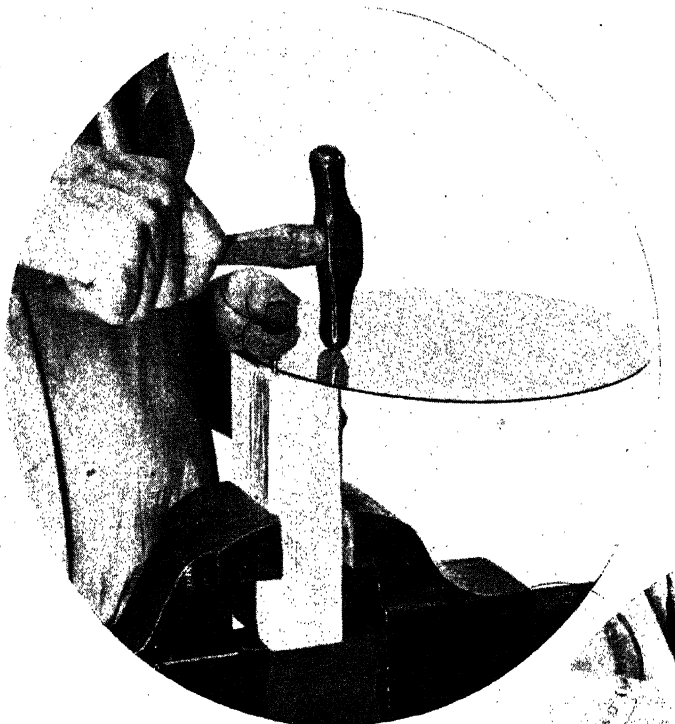


Fig. 46.
Starting to sink the well using the smaller end of the plate-hammer. Note the two nails in the wood block for guidance.

Fig. 47.
The first round of hammering completed.

Fig. 48.
Straightening the plate with a wood block and a heavy hammer.

Fig. 49.
Finishing the sinking with the broad end of the hammer.

15. Straighten the plate as shown in *Figure* 48. Use a block of wood with the corners rounded and a heavy hammer.
16. Place the work against the edge of the block of wood and use the broad side of the tray hammer, sinking it to the desired depth evenly all around, *Figure* 49.

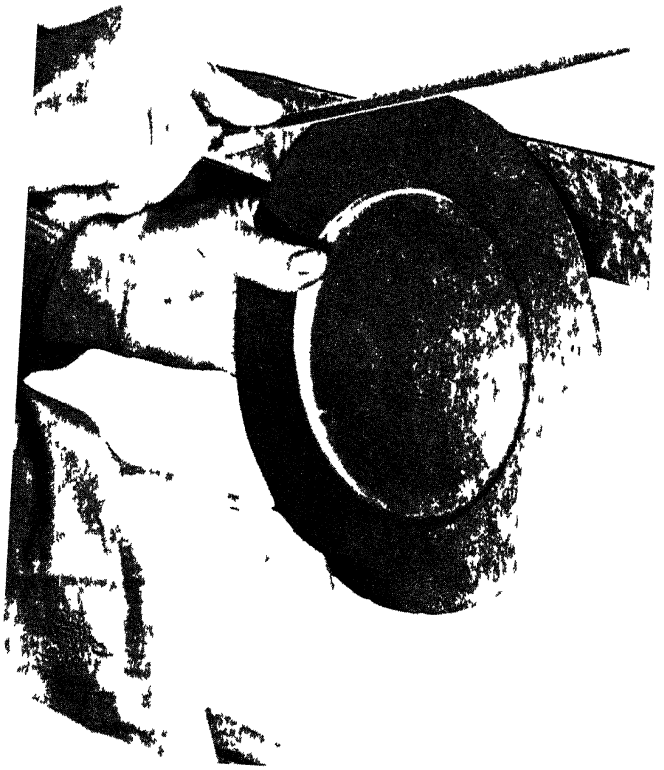
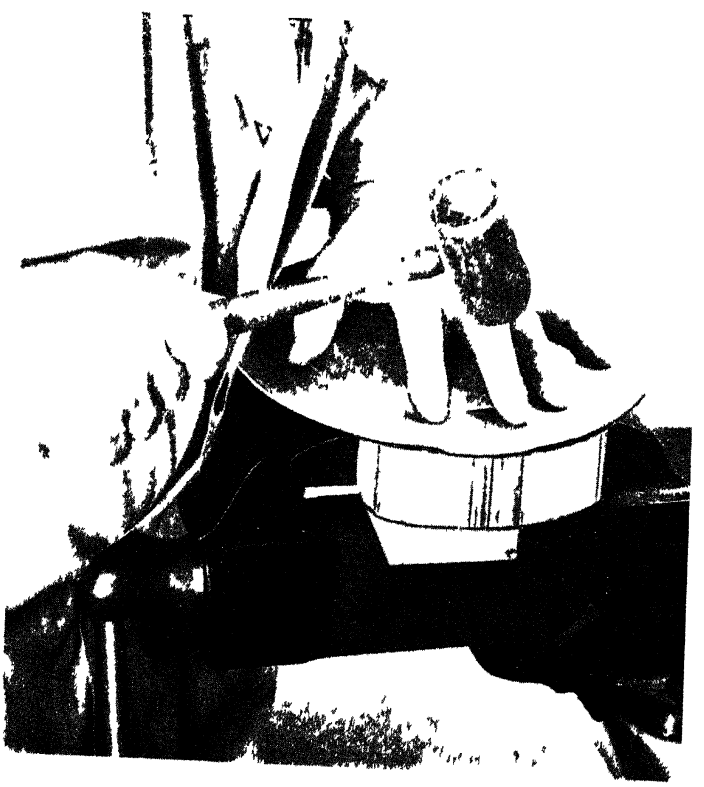


Fig. 50
Filing the edge of a plate.

Fig 51.
Turning the outer rim by hammering the metal over the edge of a wood block using a mallet.



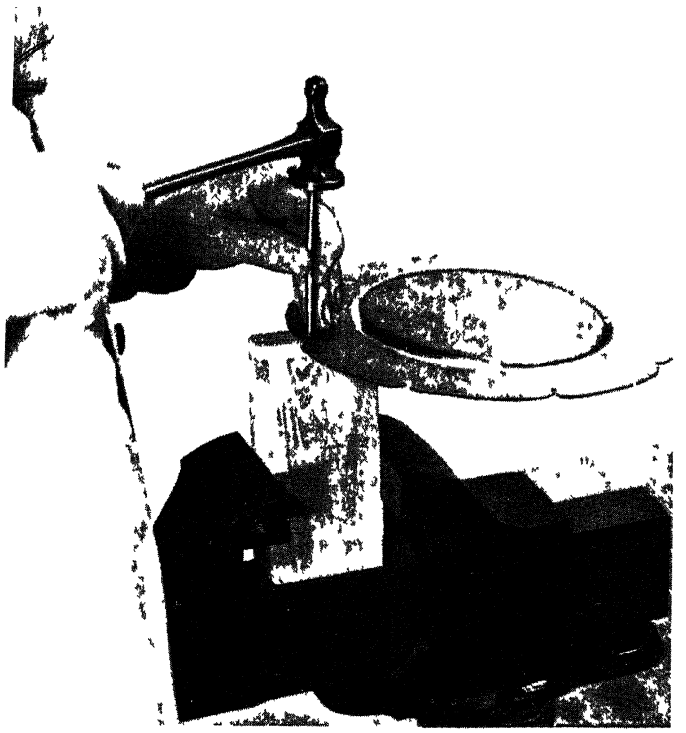


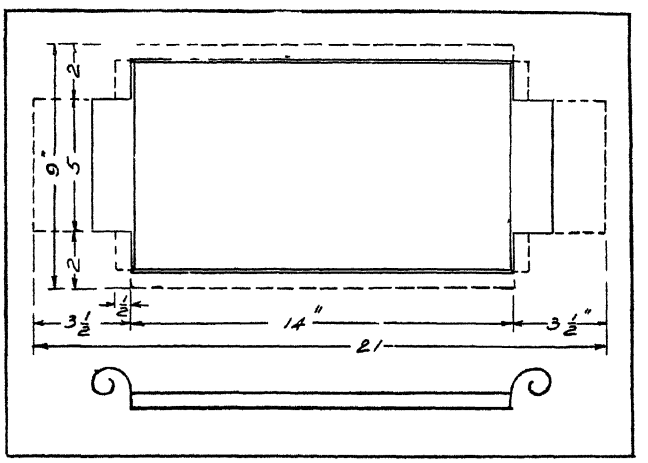
Fig. 52.
Punching small dents into the metal. Strike into the end grain of a hardwood block.

17. Straighten the plate again with the block of wood and the heavy hammer and file the edge, *Figure* 50.

When the required shape of the plate is formed, the outside edge may be enriched in many different ways by simple tooling, filing or bending, as shown in *Figures* 51, 52, 54, 55.

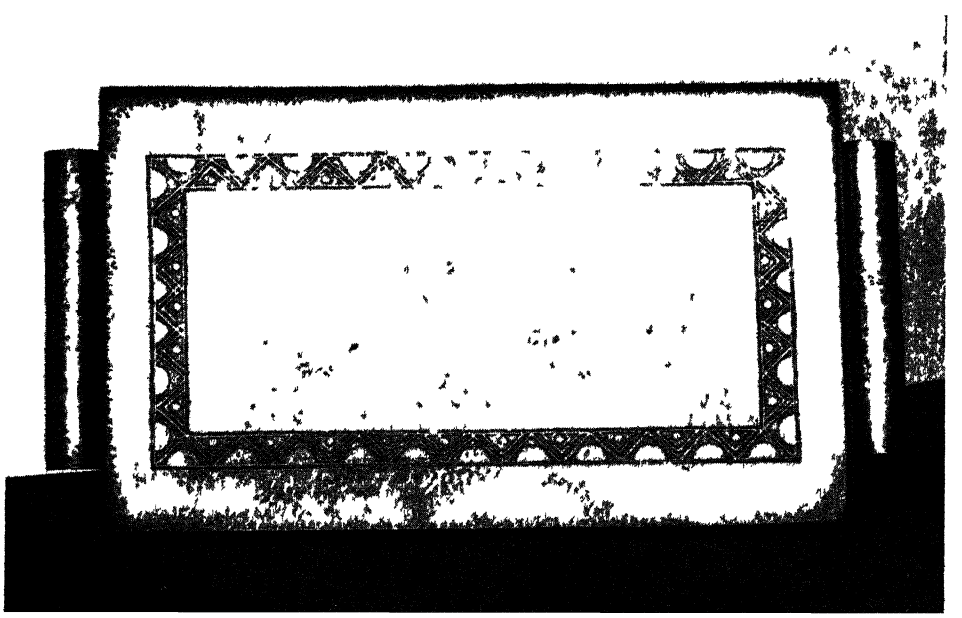
Iron tray-stakes are often used but it takes experience in hammering so as not to cut the metal against the sharp edge of the iron. Little damage can be done when the well of a plate is sunk on the edge of a hardwood block; likewise it is easier to do the planishing before than after sinking the centre. Pewter is treated the same as copper but it cannot be annealed, and allowance should be made for the softness of the metal by not striking quite so hard with the hammer.

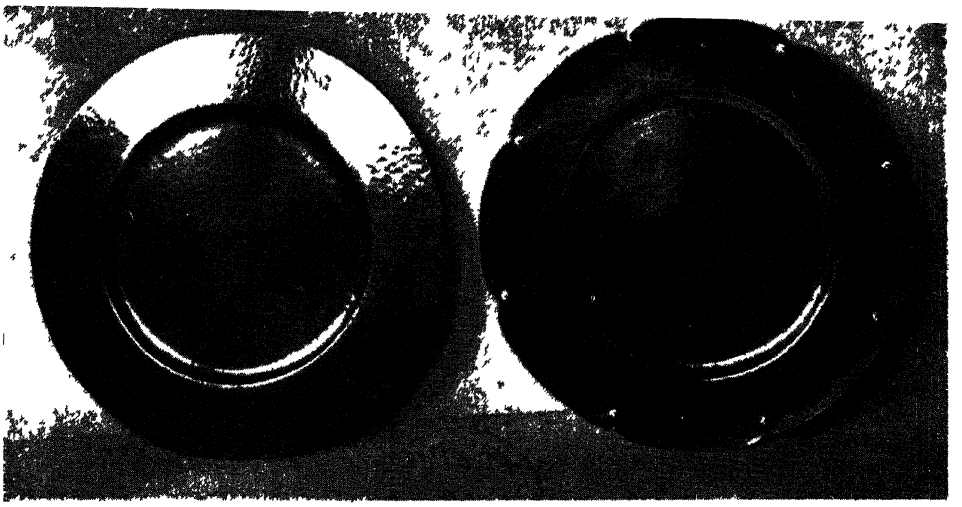
Metal trays with sharp bends such as *Figures* 53a and b must be laid out carefully. A good way is first to cut the entire pattern from a heavy manila paper and score the lines that have to be bent—in other words. make the tray from paper first. The bending of the metal is done by squeezing it between two pieces of wood held in place by the vice or clamp, then bending the metal to a right angle, using a wooden mallet and striking lightly and often.

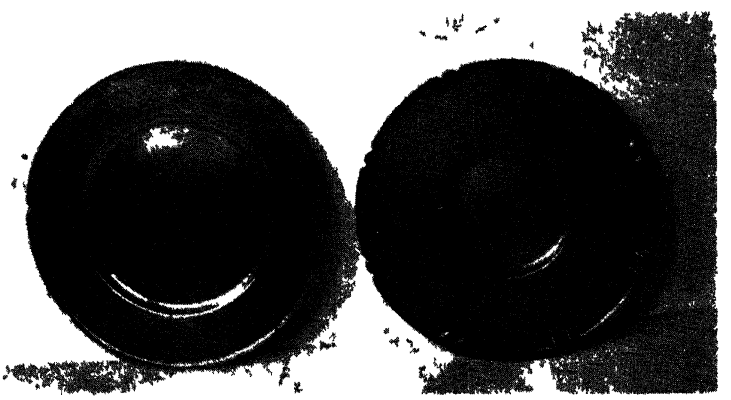


Figs. 53a and b.

Aluminium tray with sharp bent edges and etched design. Made from number 12 gauge metal. Flat trays with sharp bent-up edges must be laid out full size on heavy manila paper. Tray designed and made by Mrs. A. G Pelikan.





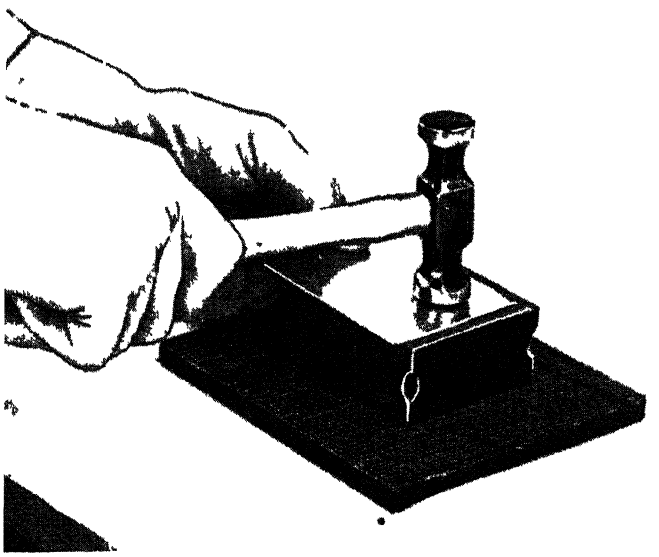


Figs. 54, 55.

Finished plates with edges enriched

Fig. 56.

Vases in copper and brass by pupils of the George Westinghouse Vocational High School, New York ; that on the right raised from a disc, the centre from a 105 *mm. shell, and the left from a section of copper tube.*



simple box construction

Fig. 57 Planishing a flat piece of metal

The copper box that is used for demonstration measures 3 by 4 by $1\frac{1}{4}$ inches in size. It can be used for trinkets, two decks of cards, or cigarettes. It is not difficult to make a simple box like this, but care must be exercised in every operation. Use cold rolled soft copper—number 20 gauge.

Method

1. Cut a strip of metal $1\frac{1}{4}$ by 15 inches long and two pieces of $3\frac{1}{4}$ by $4\frac{1}{4}$ inches.
2. Scrub and clean the metal with pumice powder and water, rinse and dry.
3. Planish the metal parts. Do not strike too hard; let each succeeding blow of the hammer overlap the previous one—then straighten the metal by gentle tapping on the opposite side, *Figure* 57.
4. Mark with a scratch awl the size of the box on the long strip of metal, using a T-square to get the lines across the metal and at right angles to the edge. See A in *Figure* 58.
5. Score the three lines where the metal must be bent. A piece of metal can be scored very much like a piece of cardboard. Use a blunt V-shaped punch or chisel with a small light hammer to cut a groove along the line to a depth of about half the thickness of the metal.

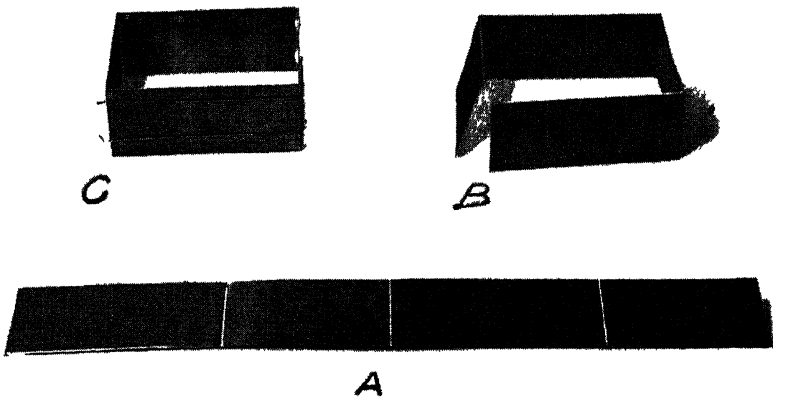


Fig. 58.
A.—The scored metal ready to bend. B.—Box sides before tying. C.—The box frame tied with soft iron wire ready for soldering.

6. With a file bevel off the ends of the metal to form an angle of 45 degrees, then bend the frame as shown in B *Figure* 58.
7. Bring the corner together by using two pieces of annealed iron wire, twisting the wire with a pair of flat-nosed pliers, C *Figure* 58.

Fig. 59.
Tying up a job with annealed iron wire preparatory to soldering.

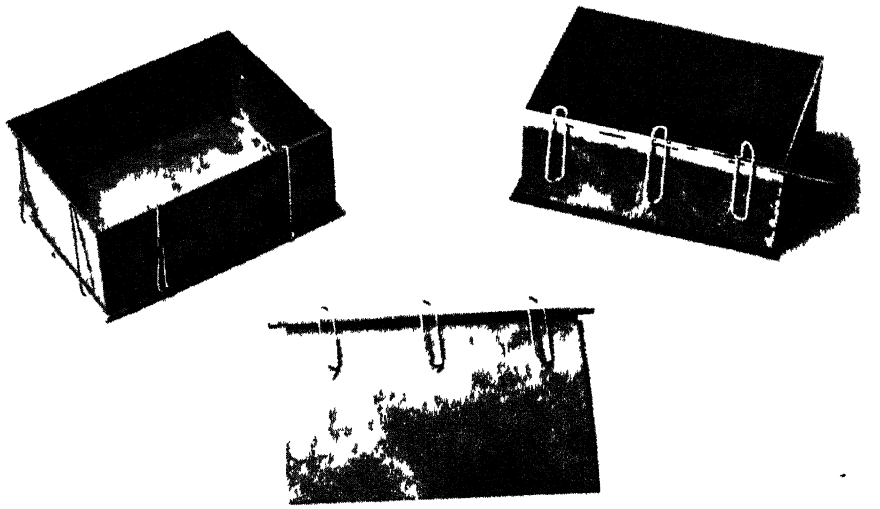


Fig 60

The tubing from which the hinge is made is soft-soldered to the box Paper clips are used for clamps

8. Hard solder the corner. This process is explained on page 26.
9. Square the frame.
10. Measure the box frame then cut the top and bottom pieces —one eighth of an inch larger than the frame.
11. Hammer the edges of the metal with a punch (chasing tool) as shown in *Figure* 26 on page 29.
12. Tie the bottom to the frame with iron wire, *Figure* 59. Rub the contact places of the metal with steel wool or an old piece of emery cloth before wiring.
13. Soft solder. This process is explained on page 23. also note *Figure* 21.
14. Draw a piece of tubing made from a strip of 24 gauge copper 5/16 of an inch wide by about 12 inches long. Pull it through the holes in the draw plate until it has an outside diameter of 3/32 of an inch. Proceed as described on page 32 (Making Metal Tubing).
15. Saw two pieces of tubing a little longer than the box. Use the jeweller's saw.
16. Straighten each piece carefully. then clean with steel wool.
17. Attach one piece to the upper edge of the box and the

other along the inner edge of the lid. Paper clips make good clamps for such purposes, *Figure* 60.

18. Apply the flux, then soft solder.

The hinges of the box are made of the two pieces of tubing now soldered on to the box. All hinges have odd numbers of joints—3, 5, 7.

Assuming a hinge of seven joints is to be made, proceed as follows : take the box, place it upside down on the table and cut off the projecting ends of the tubing with a jeweller's saw. Divide the tube left on the box into seven equal parts (this is easiest done with a pair of dividers.) Then cut the tubing with the jeweller's saw—*Figure* 61. Be sure to cut it through, but not into the box. With a pair of flat-nosed pliers the three in-between pieces can now be twisted off the box, *Figure* 62. Remove the visible solder with a scraper and finish up with a small piece of emery cloth. Now place the box against the cover and mark the opposite part of the hinge with a needle point awl, then make the cuts with the jeweller's saw as was done on the box part. The saw

Fig. 61.
Making the cuts in a piece of tubing

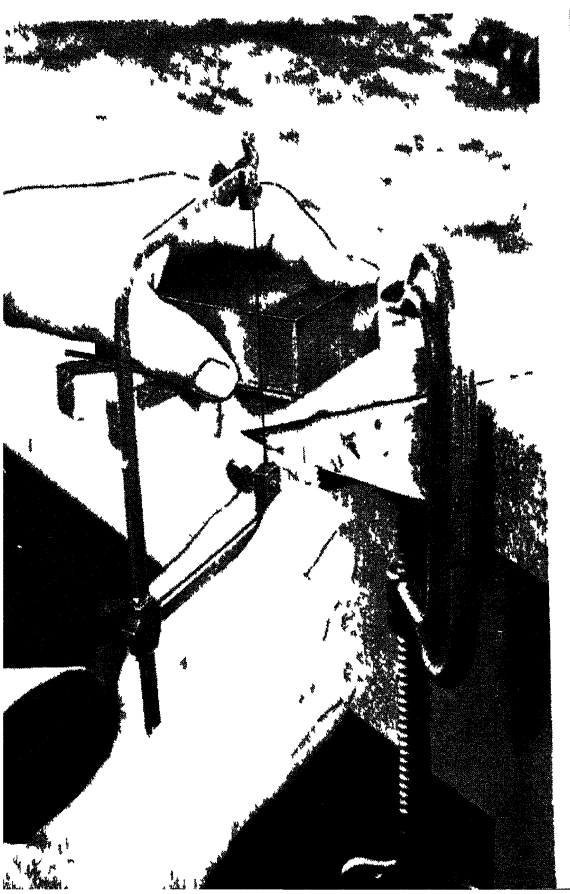


Fig 62.
Removing the in-between pieces of a hinge.

Fig 63
Making the cuts in the tubing for the opposite part of a hinge

must however, be held in a horizontal position, *Figure* 63, instead of vertically as was done when the cuts were made on the box. The removal of the four pieces of tubing is done with the flat-nosed pliers as before. If care has been exercised in transposing the measurements from the box to the cover, a nice close fitting hinge is the reward. A piece of wire having the diameter of the hole of the tubing may now be inserted to form the pin of the hinge. A paper wire clip that has been straightened and one end filed to a point is about the right size for a pin. A pair of pliers is necessary to force the pin into the hole of the hinge. *Figure* 64 shows the progressive steps and the finished box.

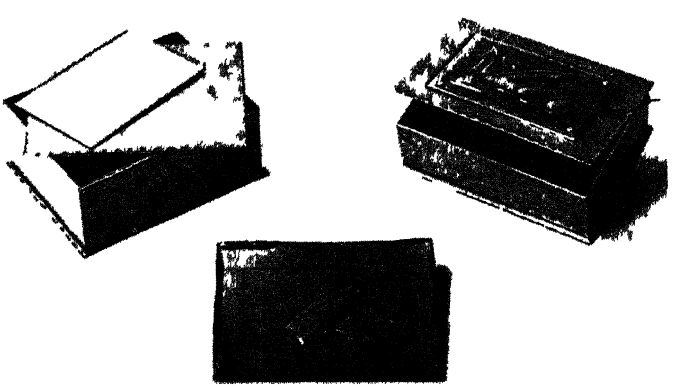


Fig 64
A hinged box with applied ornamentation.

ornamental etching

Decorative etching on metalcraft work is well within the boundary of what may be called " Simple Metalcraft." The first essential, of course, is a design suitable for its purpose ; secondly, the ability to use a small paint brush. The actual etching of the metal is more or less a mechanical and chemical process. The metal is eaten away with an acid where it is left unprotected. An acid-resisting medium such as bees-wax, paraffin, or asphaltum paint must be used as a protector.

Pictorial etching and " drypoint " work is quite different from ornamental etching. In pictorial work the artist covers a shiny copper plate with an acid-resisting gum on which he draws with a needle, laying bare those lines which he wishes to show black on the finished print. With the drawing complete, the edges and back of the plate are varnished and then put into an acid bath, which eats out the drawn lines so that ink will be held by them. A variation of depth between the blackest and lightest lines is secured by painting out the weakest lines as the biting of the acid progresses. Ink is forced into the lines and the impression transferred by a press to dampened paper. Drypoint is the art of drawing directly on the plate with a steel needle. This procedure gives a deep furrow in the copper that holds more ink than the etched lines. During the course of the printing, the sharp burr is worn away and only about 25, of a maximum of 50 prints possible from an etching, can be secured, making drypoint prints more valuable since the edition is limited.

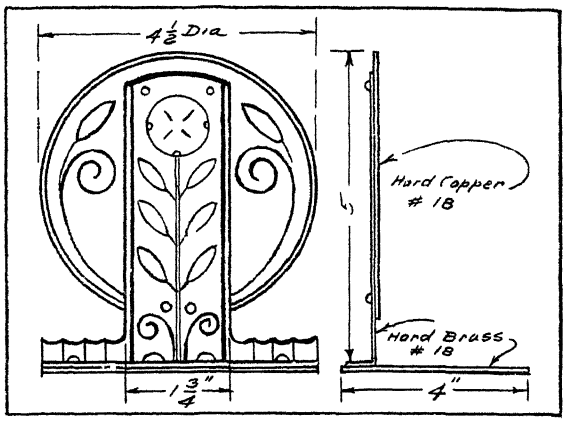


Fig. 65.
Book support made of copper and brass, suitable for an etched design

The book ends shown in *Figure* 65 are suitable for ornamental etching and the procedure would be as follows : each book-end has three parts—a circular copper disc, an upright, and a base plate of brass, and also eight rivets. With all construction work finished but not assembled :

1. Transfer or draw free-hand, the ornamental design on the upright pieces.
2. Scratch the design carefully into the metal with a sharp-pointed steel awl.
3. Scrub the metal vigorously with pumice powder and water to remove every trace of oil or grease. Rinse and dry.

At this point in the ornamental etching process most failures occur because the prepared metal is handled carelessly. After scouring with pumice and water, the metallic surface has been provided with what may be called a tooth, that will hold the asphaltum paint, or whatever acid-resisting medium is used, while the metal is being etched. A piece of work can usually be picked up and handled by holding the edges. Do not touch the surface of the metal with the fingers—keep it covered with a clean piece of paper or a rag and expose only the part that is being worked upon.

4. Paint the design with asphaltum—using a small water-colour brush. Asphaltum is a black bitumen (mineral pitch). It is acid-resisting and may be thinned to the proper working consistency with turpentine. The drying time is six to eight hours, depending on air flow and temperature.
5. Cover the reverse side of the work with asphaltum, also the edges of the metal, and put away carefully to dry as it is now ready for

the acid. *Etching solution* for copper. brass, and pewter is made by adding one part of nitric acid to two parts of cold water, but what is known to the trade as commercial acid is good enough. There is always a chemical reaction taking place where acid and waters are mixed and the mixture gets quite warm. Do not use a warm or hot etching solution.

6. Place the work in an enamelled or glass tray, pour in enough acid to cover the work. Rock the tray gently and use a feather to brush off bubbles that form on the work. The time it takes to etch varies with different metals and the depth desired. The approximate time is—copper. two hours ; brass. one and a half hours ; pewter. fifteen minutes.
7. Pick up the work with a stick of wood and rinse in water.
8. Remove the asphaltum with turpentine or gasoline.

Placing or suspending the work in a container with turpentine will dissolve all the paint without rubbing.

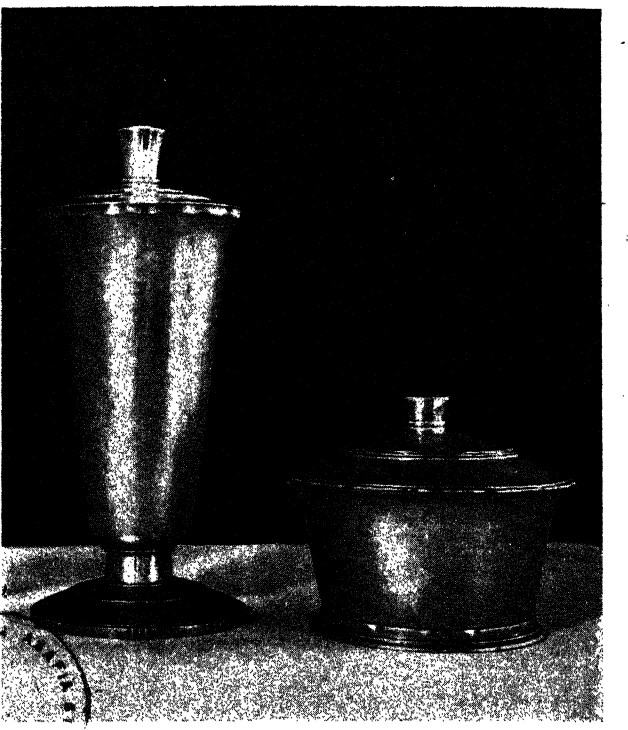
etching aluminum

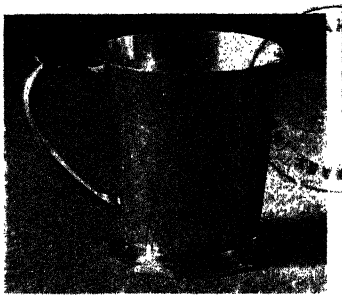
The preparation of the metal and the painting of the design is the same as for copper and brass. The etching solution is made of one part of hydrochloric acid to two parts of cold water. The actual etching process, however, is different from that of etching copper and brass which practically takes care of itself. Aluminum has a coating of an invisible oxide that prevents the acid from biting into the metal at once. but as soon as the oxide has been dissolved, a violent boiling begins and the acid becomes hot and must be disposed of or poured into another tray or crock for cooling before it can be used again. It is important to have plenty of etching solution on hand in order to make progress in aluminum etching. After the first bite of the acid the work is rinsed in cold water, then a second bite is taken of the metal with the etching solution, with again the same violent reaction, and disposition must be made of the hot acid as before. This is repeated ten to twenty times depending upon how deep a design is desired. Etching should be done near a ventilator because the hydrogen gases released by the action of the acid are not very pleasant to inhale.

A group of beautiful metalware by students of the Royal College of Art, London.

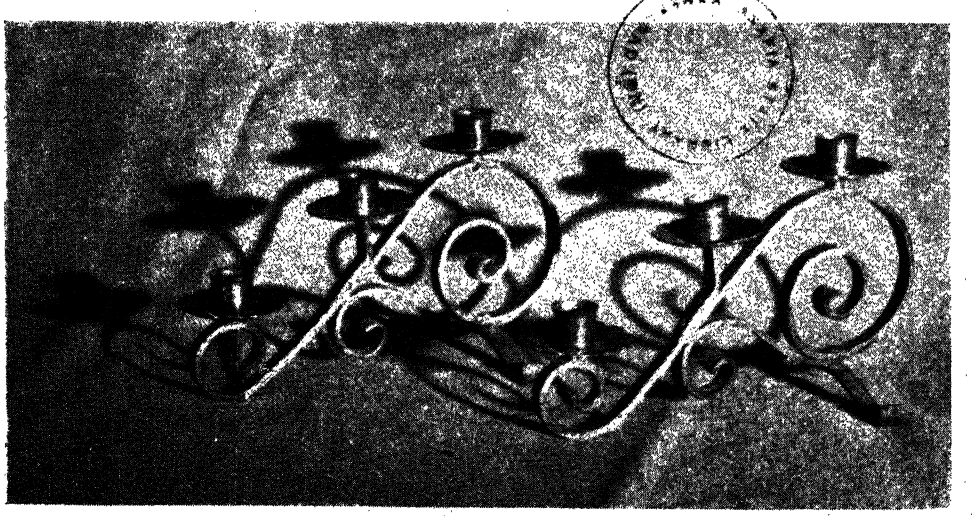
some further examples of fine metalwork

Below : A silver christening cup with chased pattern by a senior student at the Bournville School of Arts and Crafts, Birmingham.

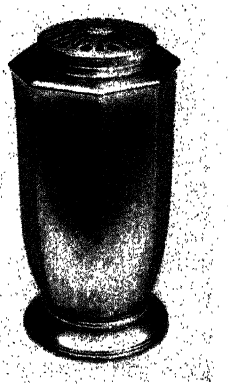


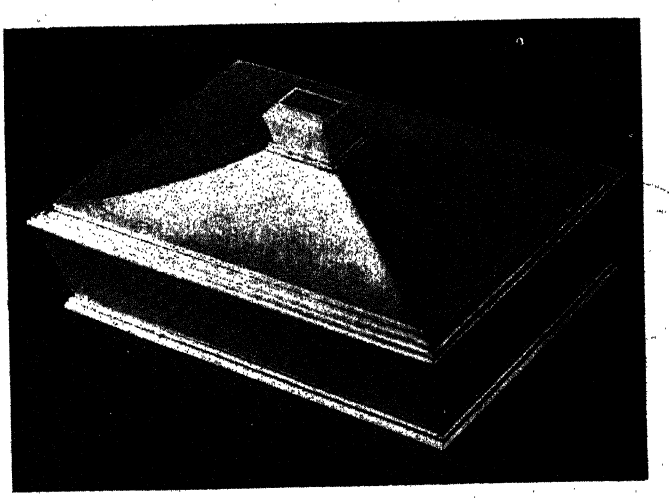


These examples are the work of junior students at the Rochester and Sidcup School of Art, Kent. Candle-holders in copper made by second-term boys at the George Westinghouse Vocational High School, New York.

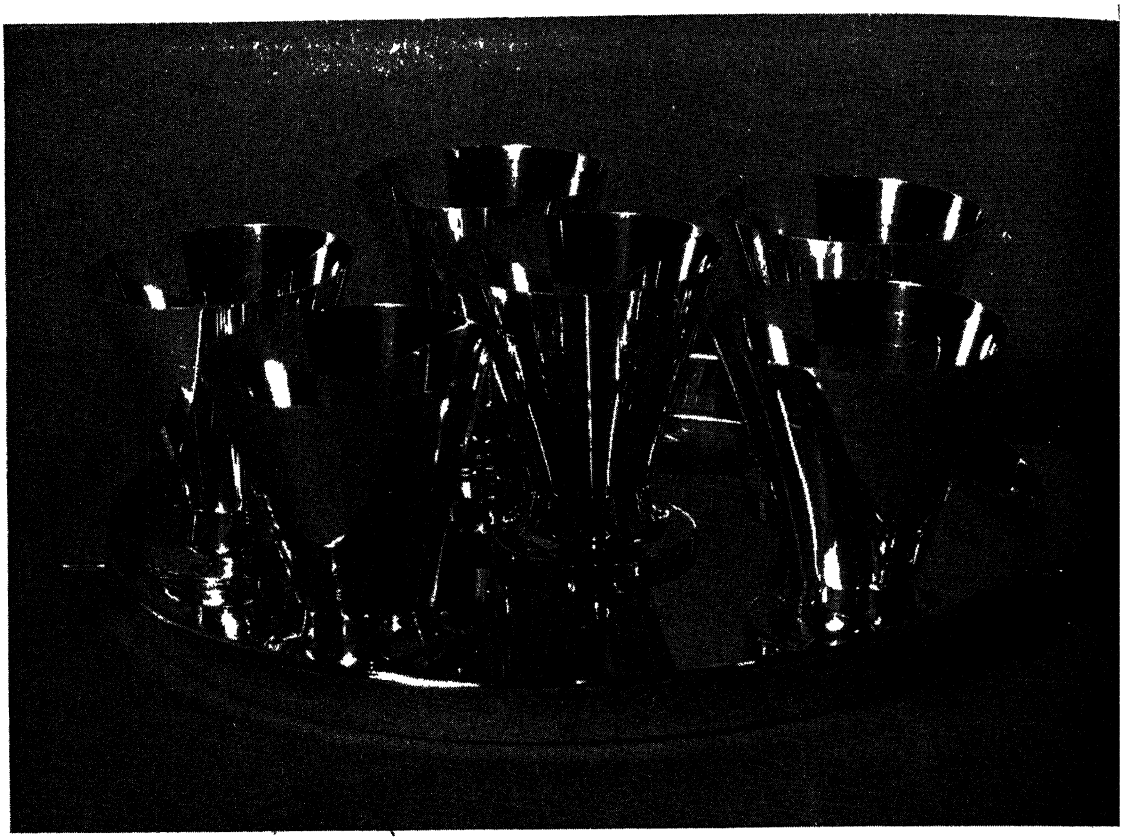


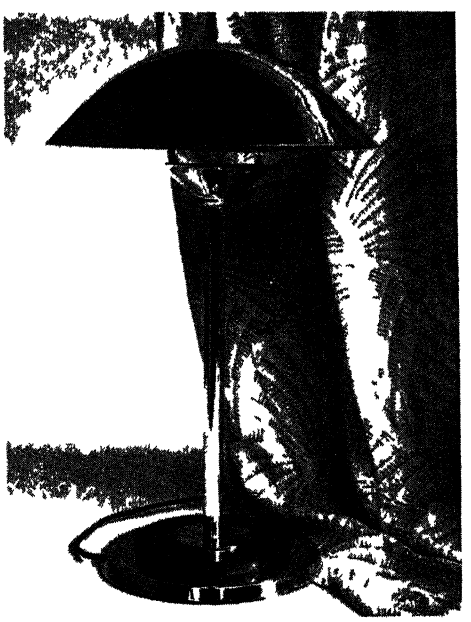
All the designs on this page are by students of the Bourneville School of Arts and Crafts. Above, a coffee pot by a senior evening student and a sugar basin by a Day Continuation school-boy.



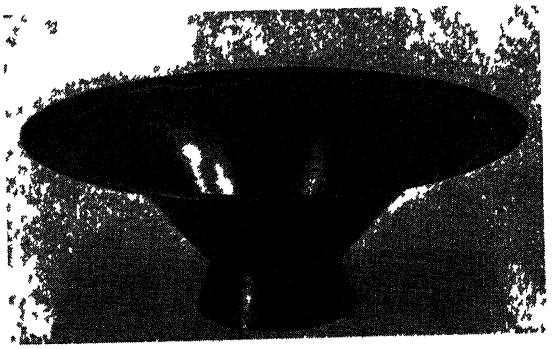


Silver sugar castor, designed and made by a senior student. Left, a cigarette box with ivory knob by a Day Continuation school-boy.

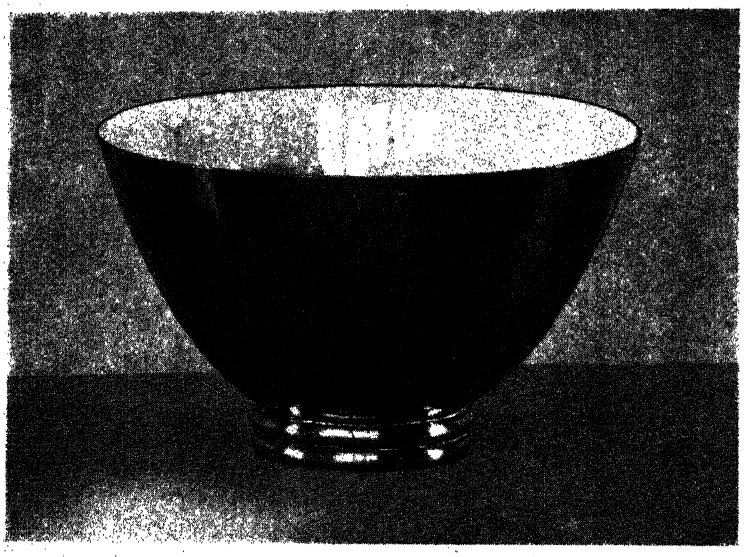


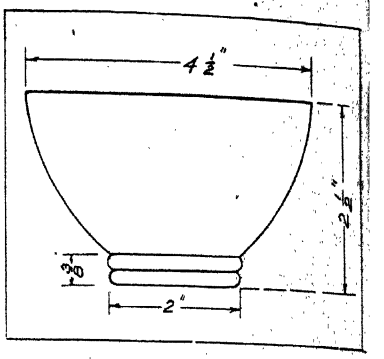


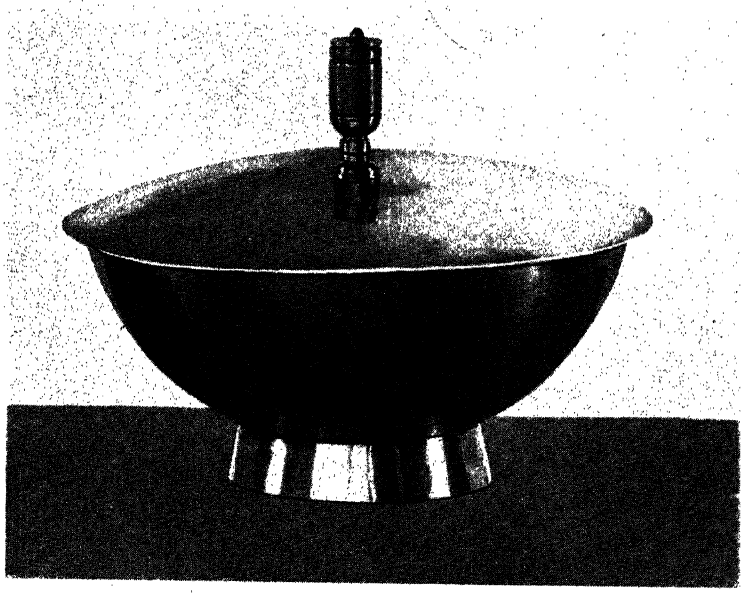
Beakers and a lamp by students of the Royal College of Art, London

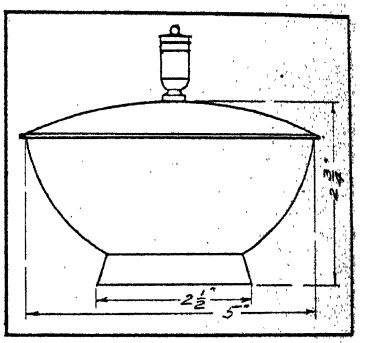


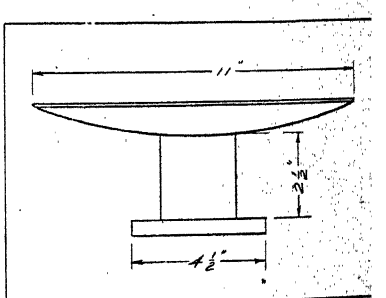
More examples of the work of the students of the Royal College of Art, London.



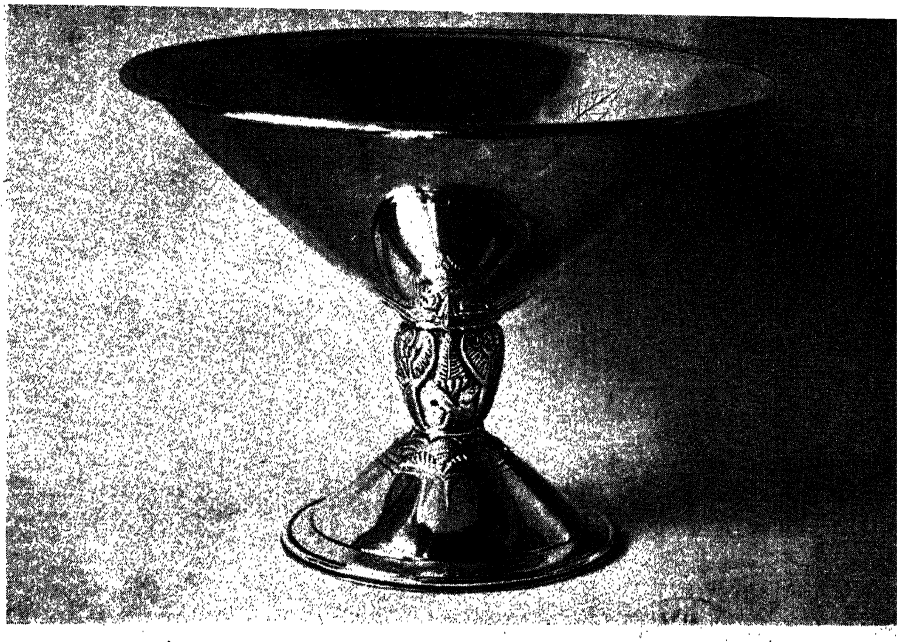






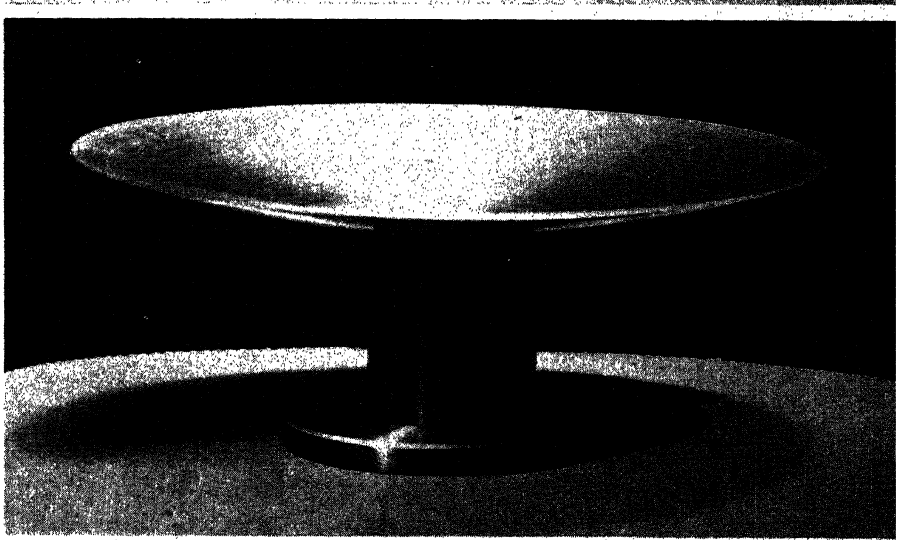


An enamelled metal bowl and a covered bowl : both designed and made by Mr. Haldon Thurn, Instructor at the Boys' Technical High School, Milwaukee.

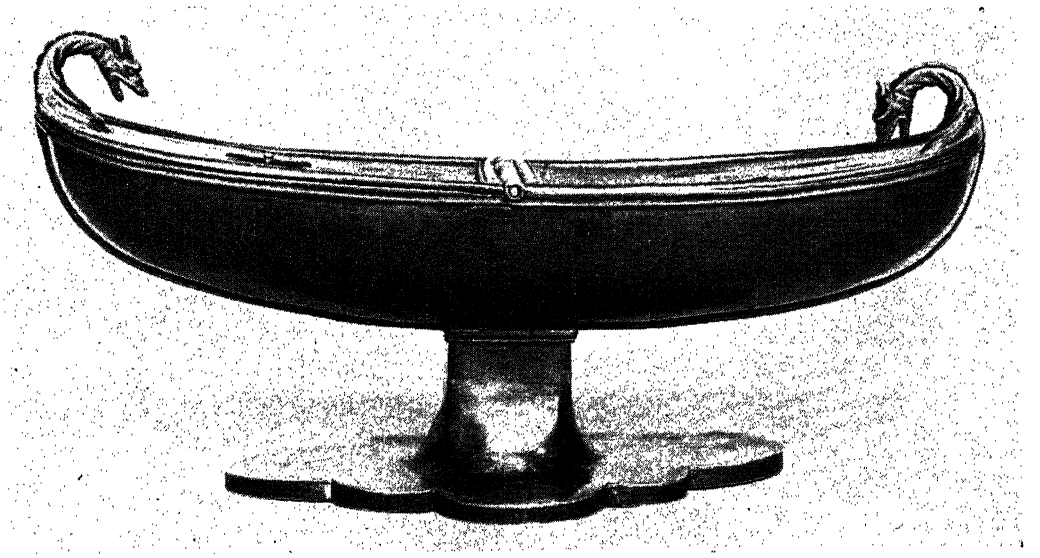


Dish designed and made by C. J. Shiner. Birmingham. From the collection of the Worshipful Company of Goldsmiths. at the Goldsmiths' Hall. London.

Silver Salver. Diameter 10½ in. Maker's mark of Joseph Ward. London hallmark for 1710-11. From the Victoria and Albert Museum. London. Frank Smith Bequest.

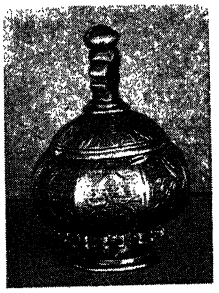


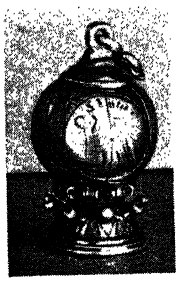
A shallow bowl: student work from the Pratt Institute. Brooklyn, New York. The working drawing is on page 62.

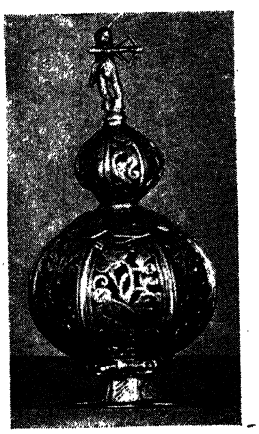


Silver Incense Boat. Fifteenth century. French. From the Taylor collection at the Victoria and Albert Museum, London.

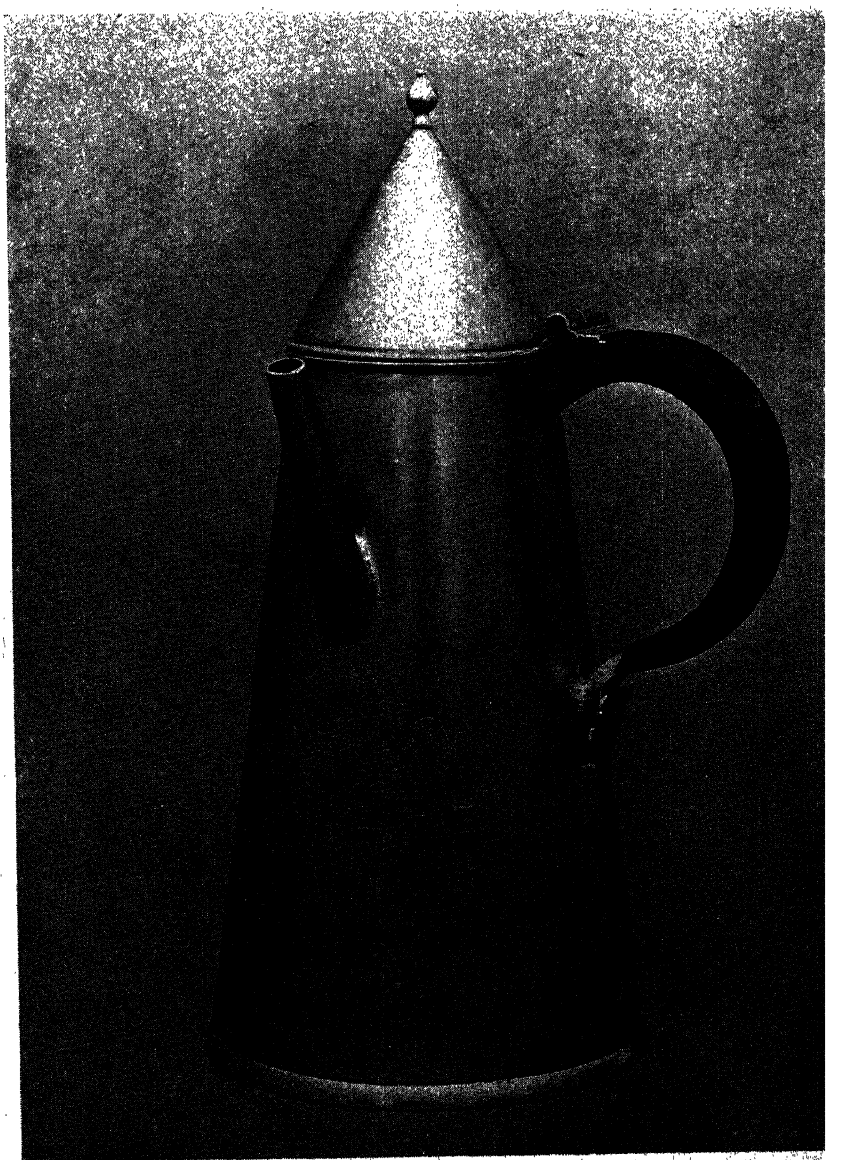
Four pomanders. Left : silver parcel-gilt pomander, English, first half of seventeenth century, $2\frac{3}{4}$ in. high. Top to bottom, page 65 : Silver-gilt pomander Spanish (Toledo), end of sixteenth century, $1\frac{3}{4}$ in. high ; Silver parcel-gilt and nielloed pomander, Italian, fourteenth century, 2 in. high ; Silver pomander, Dutch, $3\frac{1}{8}$ in. high. All from the Victoria and Albert Museum, London.



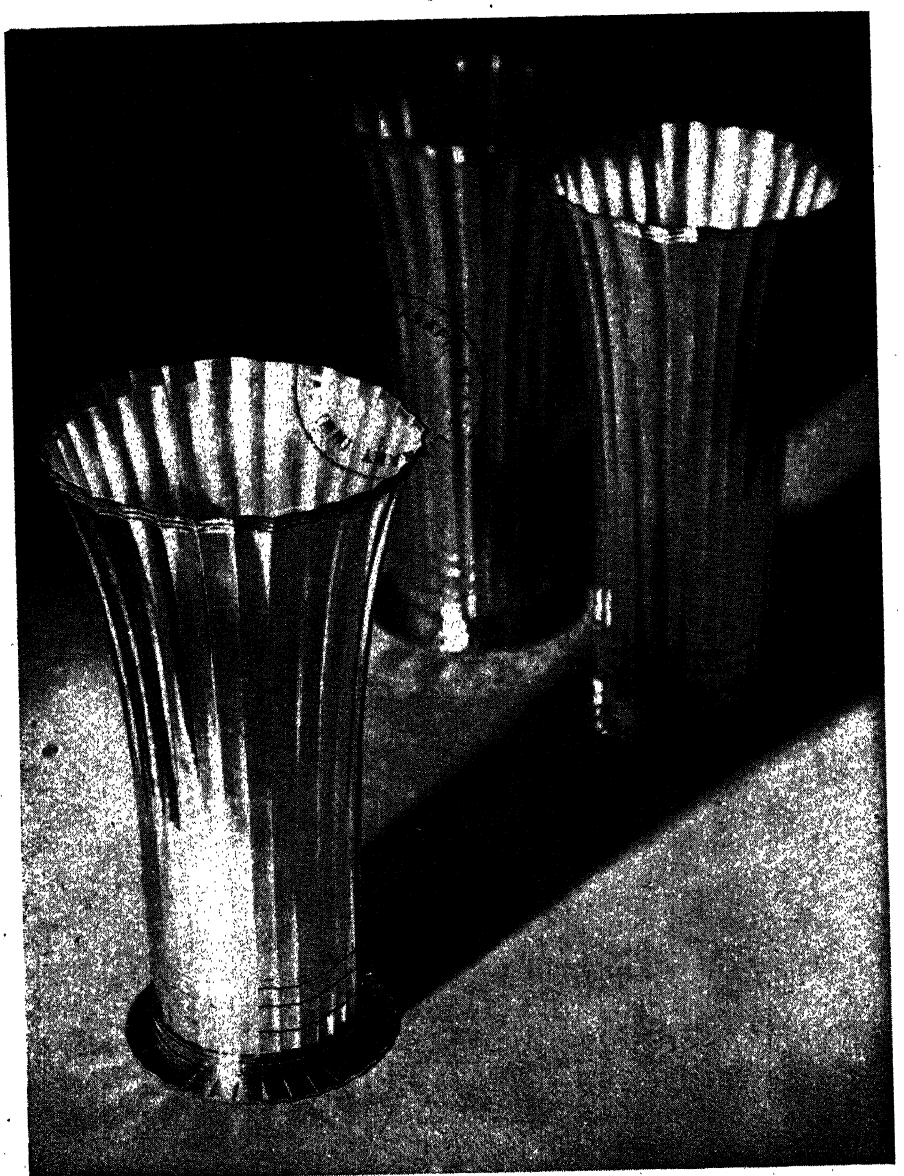


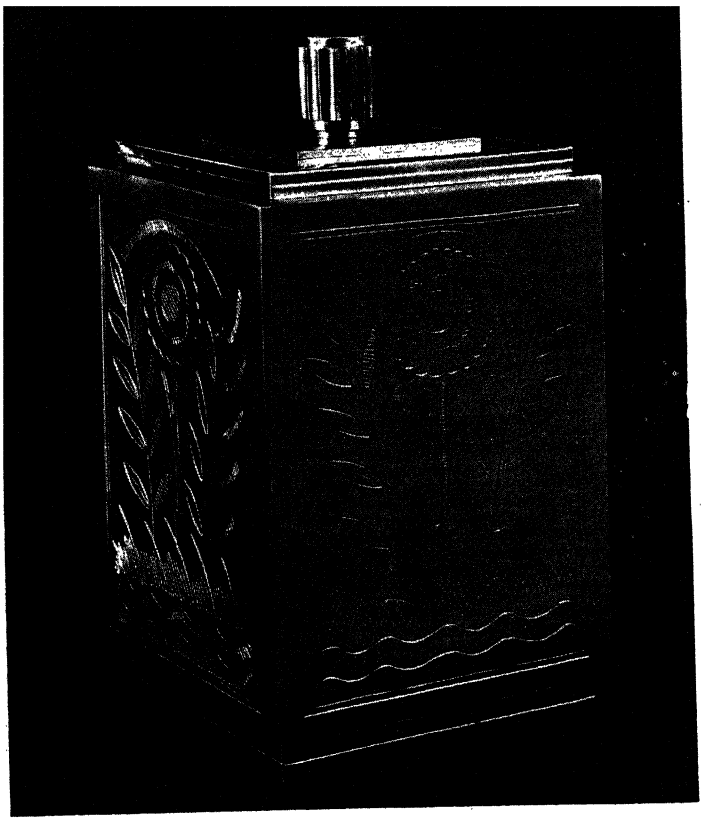


Silver Teapot. A.D. 1670. *Presented by Lord George Berkeley to the Honourable East India Company. From the Victoria and Albert Museum.*



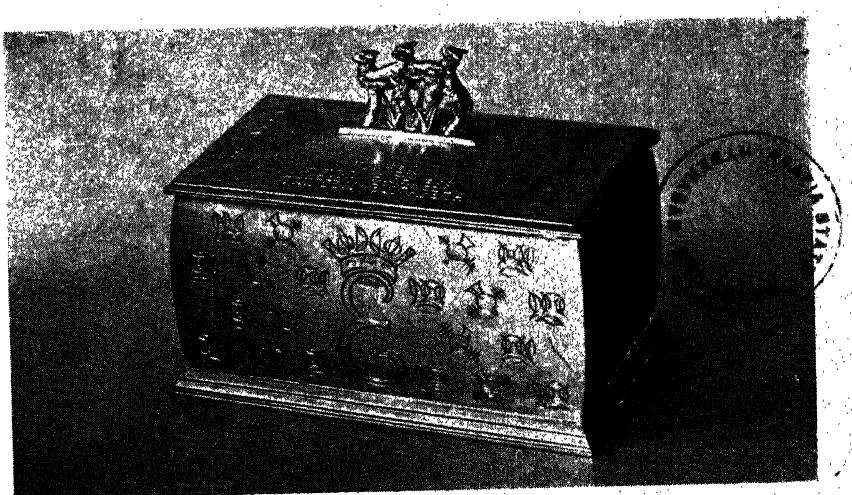
Silver flower beakers for use by the Goldsmiths' Company on the Livery Tables. Designed by Professor R. Y. Gleadowe, and made by H. G. Murphy. From the collection of the Worshipful Company of Goldsmiths at the Goldsmiths' Hall, London.

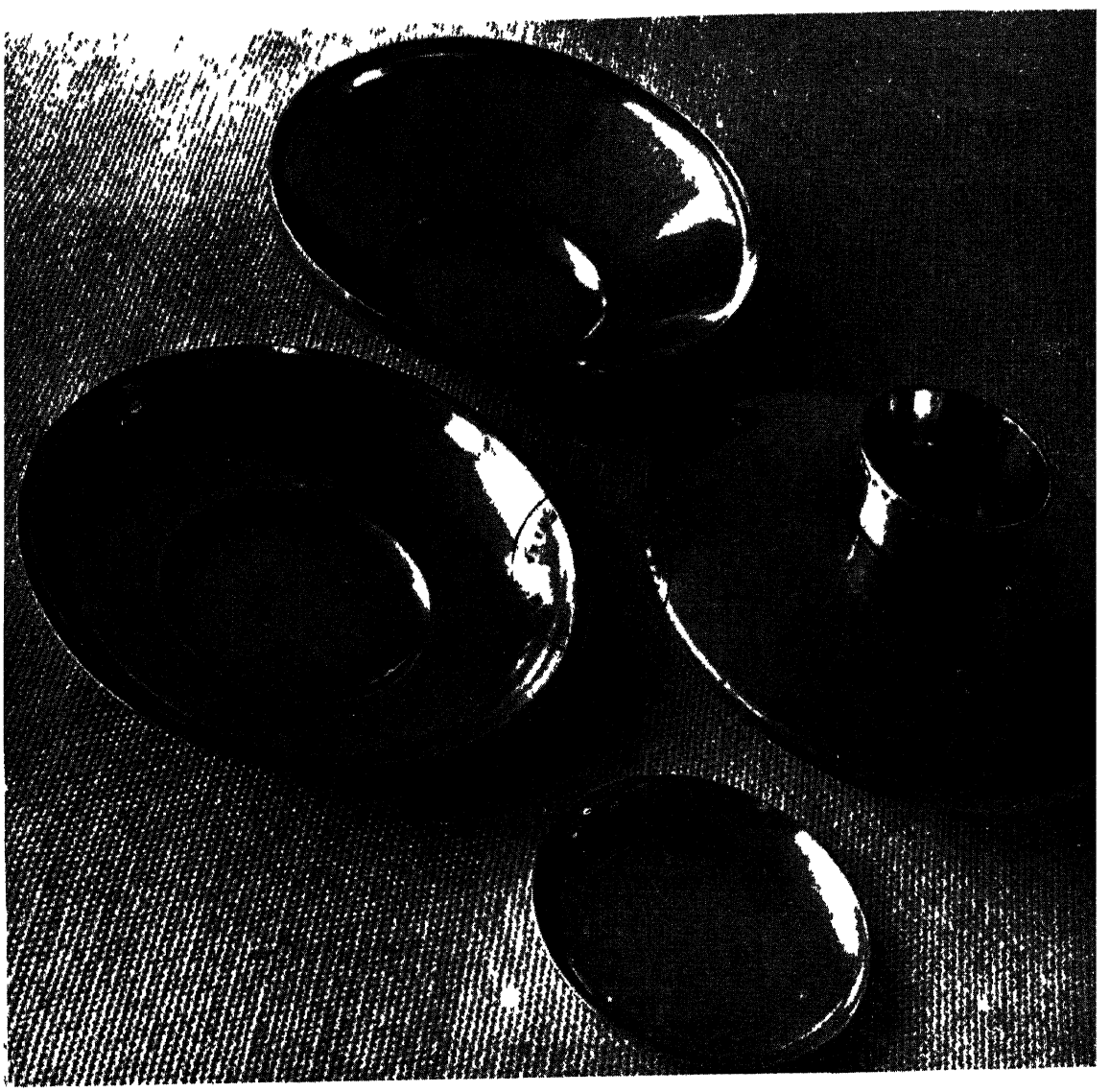




Biscuit Box designed by A. E. Poulter and made by A. R. Emerson. From the collection of the Worshipful Company of Goldsmiths at the Goldsmiths' Hall, London.

Casket designed by L. G. Durbin and presented to Queen Mary for Princess Elizabeth by the Worshipful Company of Goldsmiths in commemoration of their Exhibition of Modern Silver Work at the Goldsmiths' Hall in 1939.

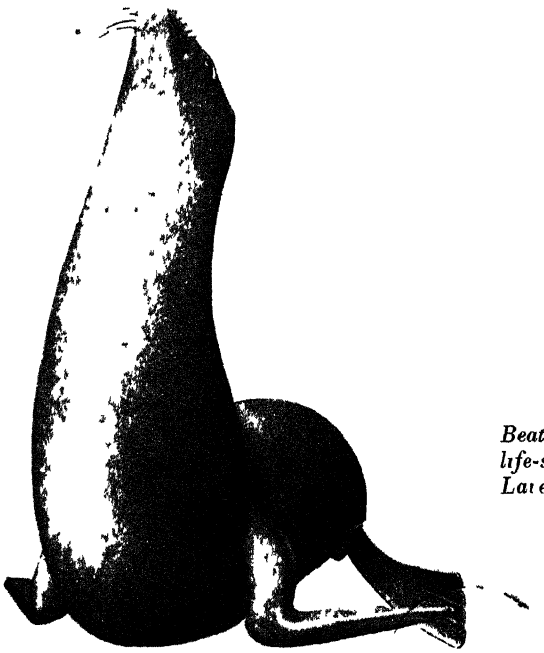




A group of hammered bowls. By courtesy of A. J. van Dugteren & Sons Inc., New York.

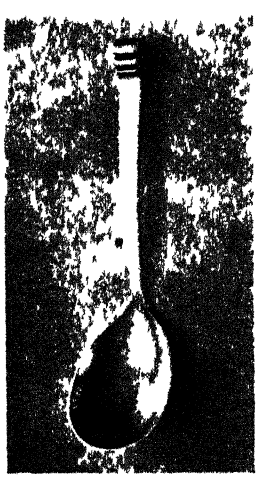
Candle-holders in beautiful modern design. By Frantz Hingelberg.

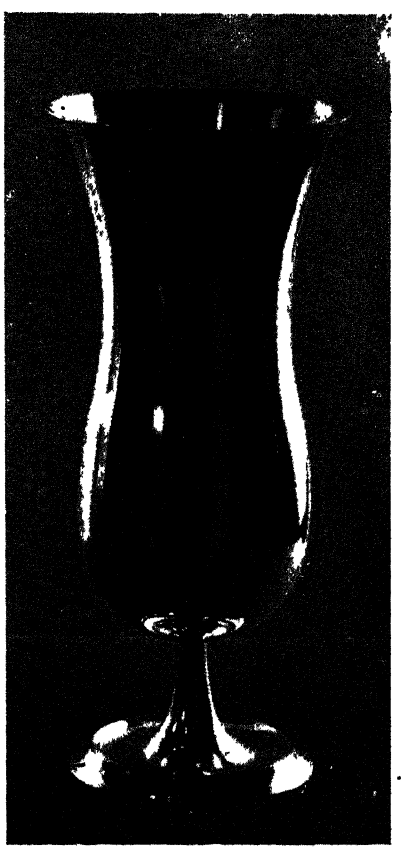
Silver fruit bowl designed by Christa Ehrlich for the Zilverfabriek Voorschoten.

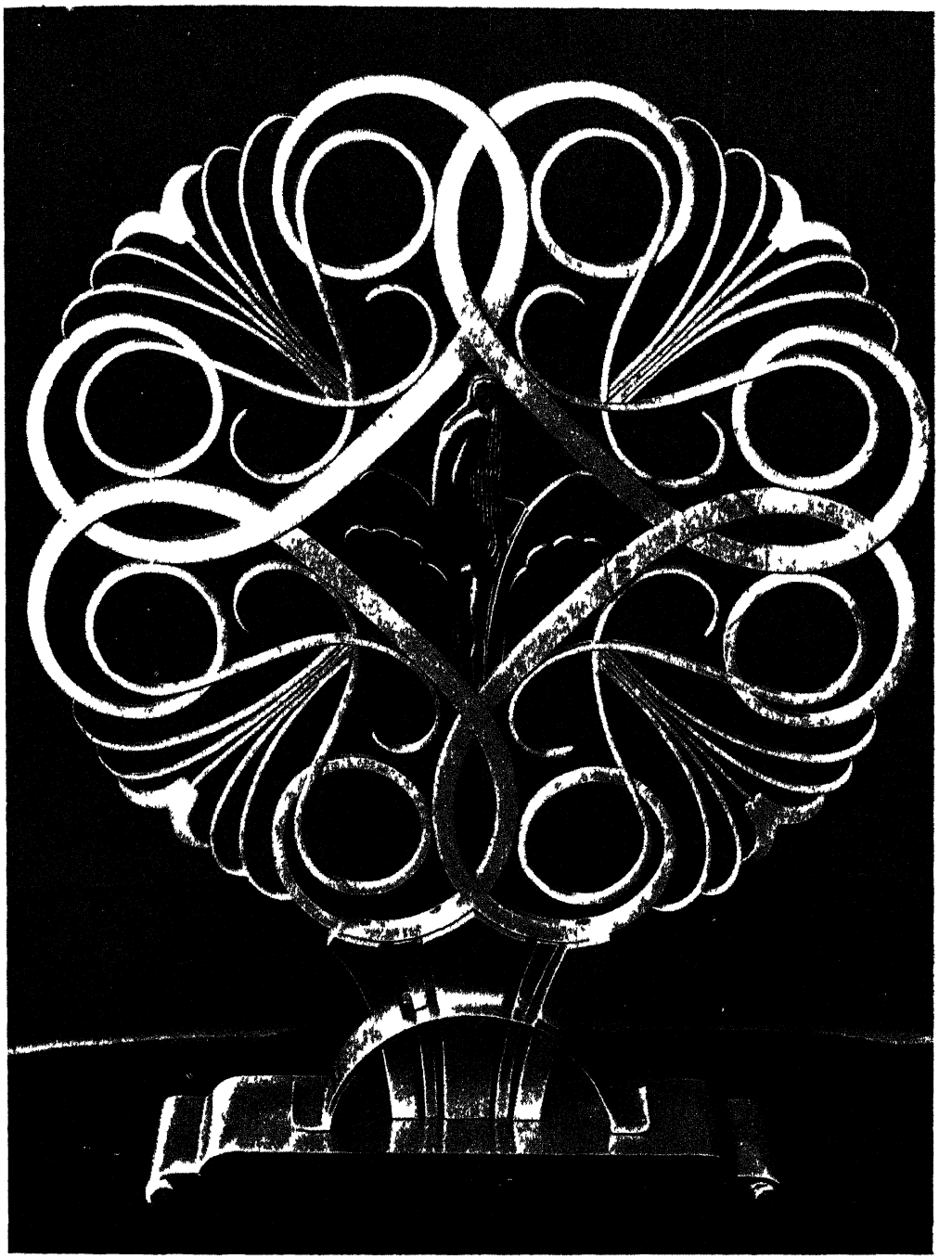


Beaten from an aluminium sheet, this life-size seal was designed by Ralph Lauers.

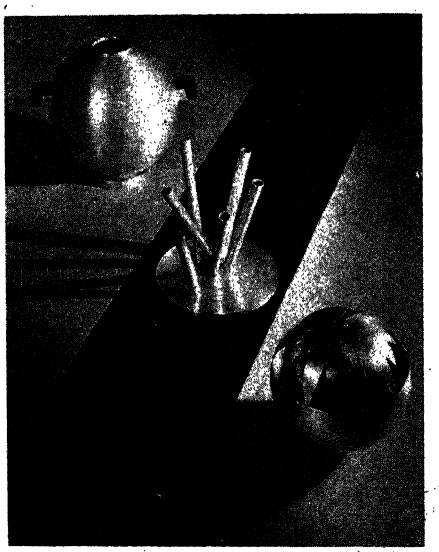
Silver serving spoon designed by the Danish silversmith, Aage Weimer. Flower vase designed by Christa Ehrlich for the Zilverfabriek Voorschoten.

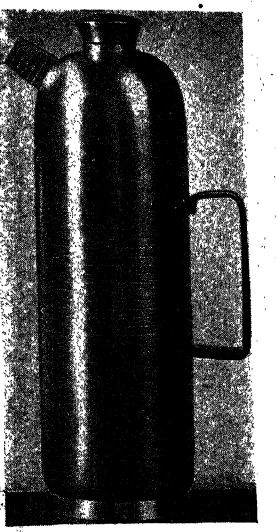




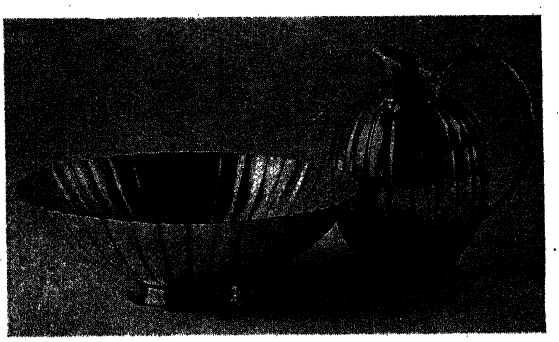


A wrought aluminium firescreen. Designed and executed by J. Starkie Gardner Ltd.

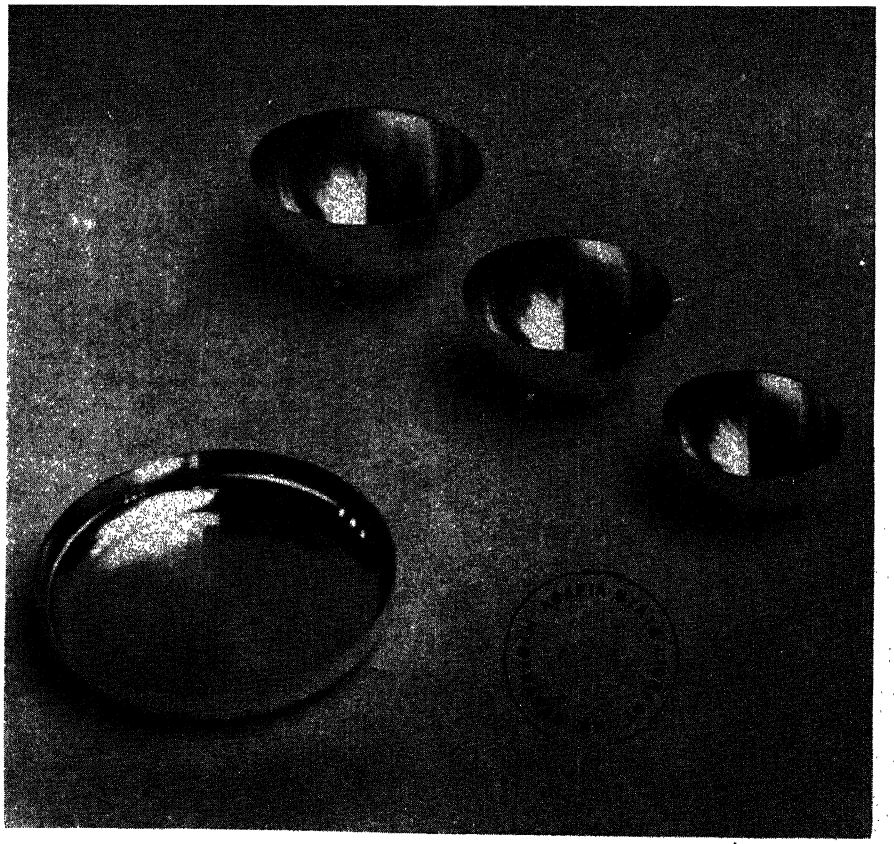




Pewter-ware: flower-holders designed by Nils Fougstedt and made by Fa Svenskt Tenn and the cock-tail shaker from Guldsmeds Aktiebolaget.

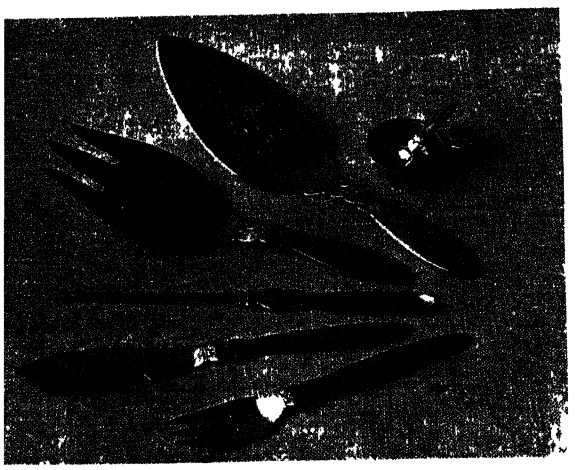


Dull-finished sterling silver fruit dish and wine jug. Designed by Sigvard Bernadotte, manufactured by Georg Jensen, Sweden. Above : silver plate, 40 cm. diameter. Wiwen Nilsson.

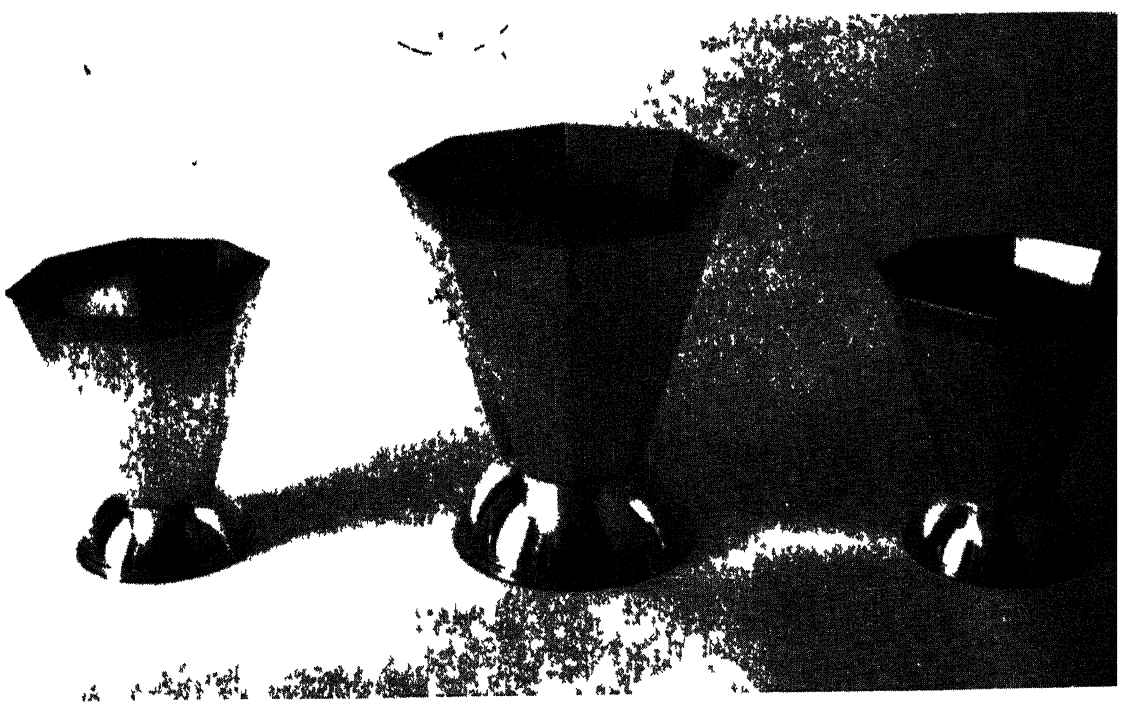


Round silver bowls.
Wiwen Nilsson.

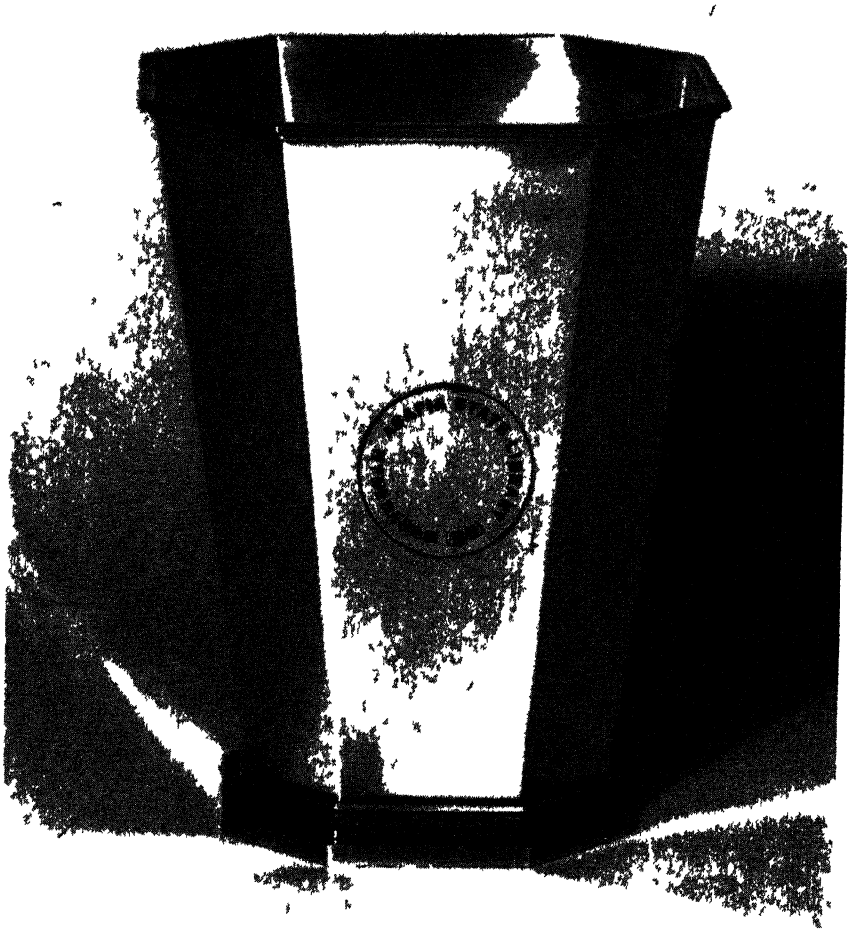
Round silver bowl designed by Helge Lindgren. Handmade by A/B Horjuvelerare K. Anderson.



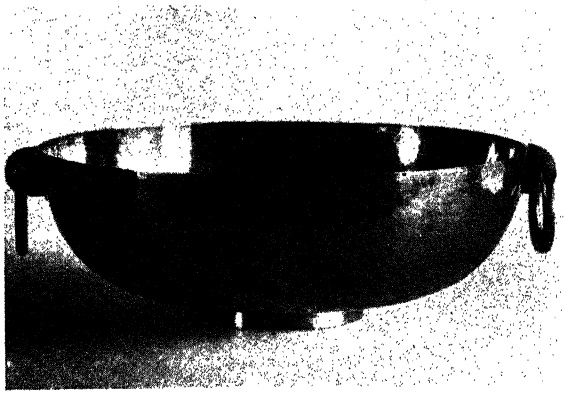
Silver fish servers, knife, fork, salt-cellar, etc., designed by Gundorf Albertus for Georg Jensen, Ltd

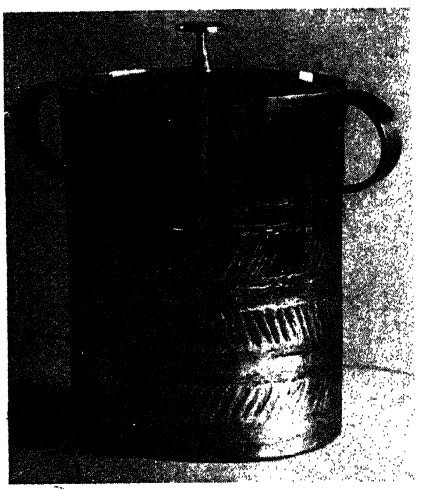


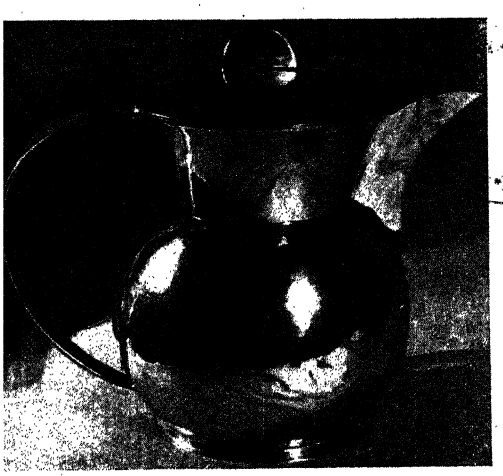
Three silver cups. Wiwen Nilsson.

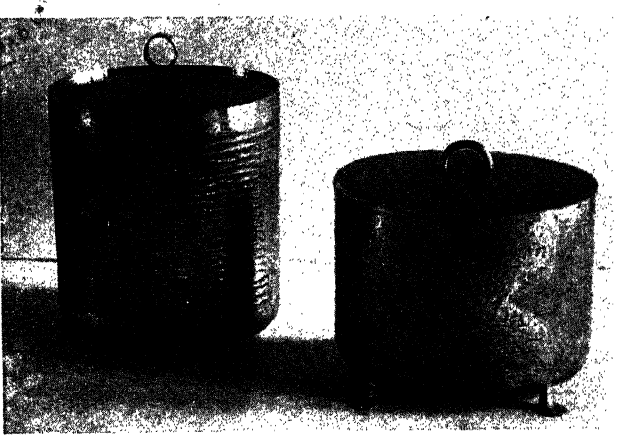


Silver octagonal cup Designed by Helge Lindgren Hand made by A B Borjuelerare K Anderson









Beaten brassware designed by Karl Muller, Germany: Fruit bowl with ring handles ; biscuit boxes with hammered decoration. Each one, except for handles and feet, beaten from a single sheet of brass. Left: Hand-beaten pewter jug (German).

bibliography

AN INTRODUCTION TO METAL WORK	T. R. Parsons (*E. & F. N. Spon Ltd., London*) 4s. 6d.
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PEWTER WORK	F. R. Smith (*Sir Isaac Pitman & Sons Ltd., London*)
PRACTICAL ENGRAVING ON METAL	G. A. Banner (*Hampton*)
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index